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THE DOUBLE SCREW FERRYBOAT BERGEN.*

THE first propeller boat for ferry purposes was built in the first decade of the century by Mr. John Stevens, and her engines are at present in the Stevens Institute.

In 1867, Mr. Edwin L. Brady, of New York, patented a screw propeller ferryboat, and two vessels of 900 tons each were built under his patent. They were, however, not a success, as the wash from their screws damaged the levees of the Mississippi, where they were tried.

Still later, about twenty years ago, Mr. F. B. Stevens made a model of a double ended propeller boat. In August, 1879, the Oxton, a double ended boat with twin screws at each end, was placed on the Mersey for service between Birkenhead and Liverpool, and since then a number of similar vessels have been built and proved perfectly successful. Four years ago Mr. Cowles, of New York, suggested a double ended screw boat, in which both screws were driven by one engine, and a deep immersion obtained by toggle joints on each side of the engine bed.

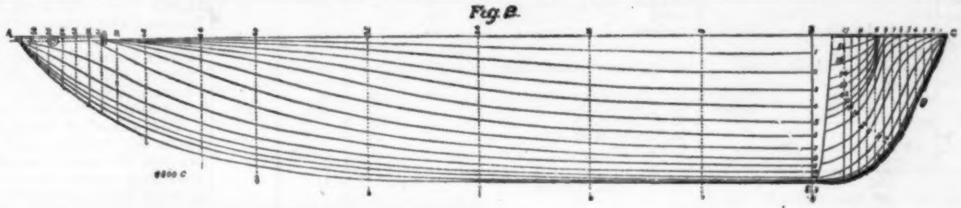
In December, 1887, the steamer St. Ignace was built to the designs of Mr. Frank Kirby. This vessel is 250 feet long, 50 feet in beam by 22 feet depth of hold. She has two compound engines each driving a propeller at opposite ends of the boat, the forward engine propeller being smaller and less powerful than the after one. This arrangement was adopted because it has been found that propeller vessels make better headway through heavy ice by going stern foremost. Mr. Kirby's idea was to have a forward auxiliary screw to project a stream of water in front of the vessel, in this manner breaking up the ice and allowing the vessel to proceed. Thus when the waterway is blocked with ice, the two propellers of the St. Ignace work against each other, and the boat is propelled solely by the difference in the powers of the two screws. In spite of this, however, this boat makes better time than any of the other vessels performing a like service.

The problem of constructing a screw ferryboat for Hoboken has been a long standing one, and in 1885 it became evident that two new boats must soon be built, but owing to insufficient time for maturing the necessary plans, it was decided to build the vessels required of the ordinary side wheel type, but at the same time Mr. E. A. Stevens and Captain C. W. Woolsey commenced a series of experiments which, two years later, resulted in a double screw vessel named the Bergen.

The water lines of this vessels are shown in Fig. 2. Her characteristics are a full flaring upper body,

* Summary of a paper read before the American Society of Mechanical Engineers at New York, by F. A. Stevens, associate, and J. E. Denton, member. The illustrations, Figs. 1, 2, 3, 4, are from *Engineering*.

Fig. 2.



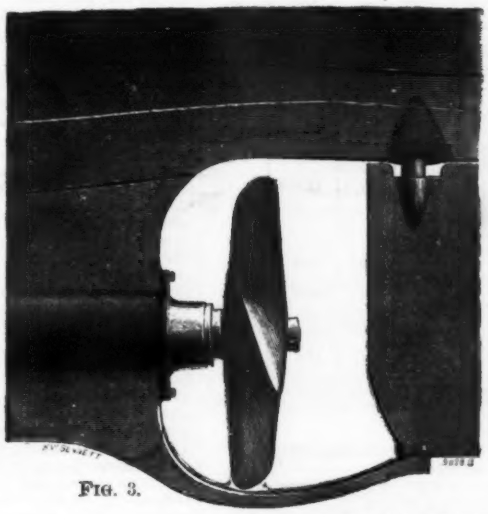
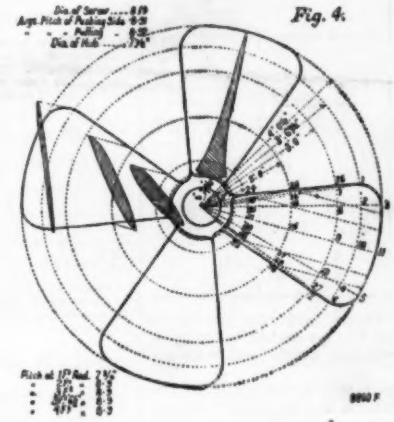


FIG. 3.

Fig. 4.



THE DOUBLE SCREW FERRYBOAT BERGEN.

FIG. 3.

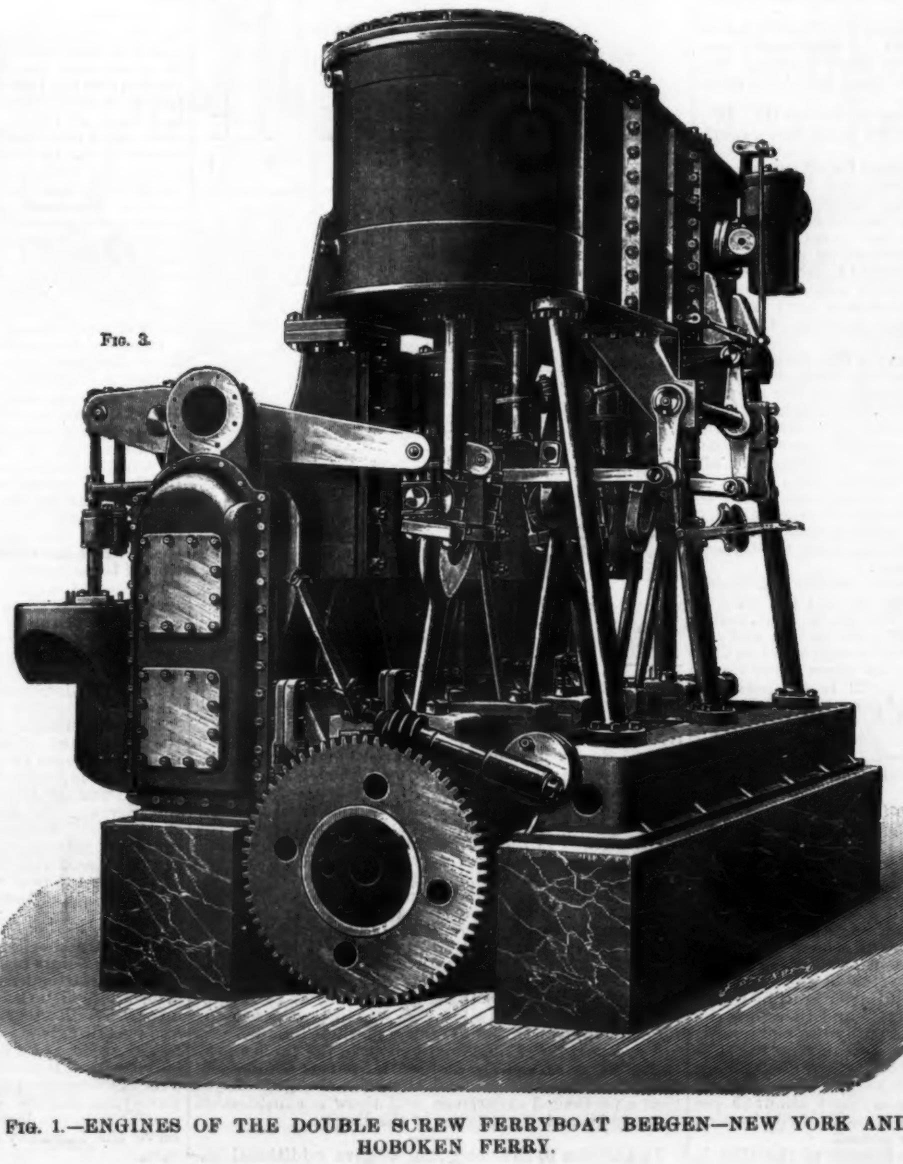


FIG. 1.—ENGINES OF THE DOUBLE SCREW FERRYBOAT BERGEN—NEW YORK AND HOBOKEN FERRY.

fine under-water body, with a full water line, a sharp V shaped midship section and a peculiar cutting away of the ends, so as to bring the rudders and screws within perpendiculars of the stems. To fulfill all the necessary conditions the form adopted was about the only practicable one, and experience on the Hoboken ferry had, moreover, been very favorable to the V section, which was in this case required in order to get a sufficient depth for an unbroken line of shafting from end to end of the vessel, on a moderate displacement.

The rudder and screw adopted are shown in Fig. 3, and fuller details of the screw are given by Fig. 4. Its dimensions are as follows: Average pitch for pushing side of blade for points, 8·911 ft.; average pitch for pulling side of blade for the same points, 8·920 ft.; projected area of blades in per cent. of disk area, 53·1; area of boss, 3·5 sq. ft.

Both screws are keyed on one continuous shaft running from end to end of the vessel and driven by a set of triple expansion engines with jacketed cylinders shown in Fig. 1, which were designed by Mr. Wilson, of Philadelphia.

The main engines take steam through a separator attached to the steam pipe near the high pressure steam chest. The jacket space around each cylinder is used as the steam chest for that cylinder. Steam to drive the circulating pump is taken from the first receiver, that is, the steam chest of the intermediate cylinder. Steam to drive the feed pump, bilge pump, ventilating and steering engines, is taken directly from the boiler through reducing pressure valves set to maintain 30 lb. pressure.

The pumps, etc., are arranged to exhaust either into the main condenser or overboard against atmospheric pressure.

When the Bergen was completed it was determined to make a number of comparative experiments between one of the old type of boats named the Orange. Particulars of both boats are given below.

The Orange is a paddle boat built of steel in 1887. The paddles are 21 ft. in diameter outside the floats, which are 20 in. deep by 4 ft. long. The engines, of which particulars are given in Table II., are condensing beam engines.

The tests were carried out by Professor J. E. Denton, and the following programme was gone through:

1. The steam consumption, boiler evaporation, horse power, and speed were determined for each boat during fourteen hours of regular ferry service.

2. Each was run to Newburg and return, a distance of 120 miles, without stoppage, and the steam consumption per horse power determined at the maximum capacity of the boilers. Also the evaporative economy of the boilers, starting with new wood fires, was determined dur-

TABLE I.—DIMENSIONS AND WEIGHTS OF ORANGE AND BERGEN.

Dimensions.	Orange.	Bergen.
Length	211 ft.	200 ft.
Beam	32 "	32 "
Draught above base of hull	7 " 8 in.	8 " 10 in.
Immersed surface	5,571 sq. ft.	5,788 sq. ft.
Augmented surface	7,347 "	7,524 "
Coefficient of augmentation	1·318	1·299
Mean angles of water lines	14 deg.	13 deg. 13 min.
Weights.	lb.	lb.
Boiler	76,000	100,852
Water in boiler	60,000—136,000	55 000—155,852
Propelling wheels	80,000	6,000
" wheel shaft	24,000—104,000	27,000— 33,000
Engines, without propelling wheels and shaft, but including frame, keelsons, etc	122,000	122,000
Fresh water tanks filled, donkey pumps, attachments (piping, chimney, etc.)	80,000	86,000
Total machinery burden, exclusive of steering and ventilating engines	542,000	396,852
Hull as launched	800,000	720,348
Total weight, machinery and hull, as launched	658 tons.	558 tons.

TABLE II.—GENERAL SUMMARY OF MACHINERY OF FERRYBOATS ORANGE AND BERGEN.

—	Orange.	Bergen.		
		High.	Intermediate.	Low.
Engine.				
Diameter of cylinders, in	46	18½	27	42
Stroke, ft	10	2	2	2
Cut-off	0·45	⅝	⅝	⅝
Clearance, per cent	3·7	16	10·7	11·3
Total expansion	2·1	....	9	....
Area of admission ports, per cent. of piston	....	12	12½	11
Boilers.				
Total heating surface, sq. ft	3,049	.....	3,462	....
Superheating " "	...	.....	....	...
Grate area, sq. ft	80	.....	81	...
Ratio of grate to heating surface	38	.....	43	....

ing an interval of fourteen hours, and the speed was measured by an estimate of the probable velocity of tides, and a log whose correction coefficient was approximately known.

3. The speed of the Bergen was determined at the maximum horse power for which the engines were designed, by opposite runs over a one mile course, after allowing the boiler pressure to accumulate above the average pressure which the boilers can maintain for more than a few minutes.

4. One of the screws of the Bergen was removed, and the power and speed determined by runs over a two mile course, first with the single screw pushing and then with it pulling the boat at equal speeds of revolution of the engine.

The principal results are shown in Tables III., IV., and V., and the conclusions drawn from the experiments are as follows:

1. The steam used per horse power for all purposes is 25 lb. per hour for the beam engine, and 22 lb. for the triple engine, under their average conditions of ferry service; but the consumption of the Bergen's main engine is only 18·3 lb. per hour per horse power, the direct acting steam feed and circulating pumps, etc., consuming about 3¾ lb. per indicated horse power.

2. The steam consumption of both engines does not practically differ while in intermittent ferry service from that found during continuous working of the engines.

3. The economy of the drop return flue boiler of the Orange is practically the same as the locomotive type in the Bergen, both boilers evaporating on the average about 8½ lb. of water per pound of bituminous coal, under ordinary working conditions, thus making the consumption of coal per hour per horse power about 2·9 for the beam engine, 2·6 lb. for the Bergen for all purposes, and 2·15 lb. for main engines alone.

4. The speed of the boats under all conditions is practically in agreement with the law of cubes, and by the application of this law it appears that for a still water speed of 12·6 statute miles per hour the following statements are practically true:

The paddle wheel boat would require 642 horse power, and would make 24⅝ revolutions per minute with a slip of 26 per cent. The screw boat, using double screws, would require 680 horse power, and engine speed of 145 revolutions, and the slip would be 12⅝ per cent. The screw boat, using one screw at the stern, would require 584 horse power, 152 revolutions per minute, and the slip would be 18 per cent. The screw boat, using one screw at the bow, would require 692 horse power, 163 revolutions per minute, and the slip would be 18 per cent., but the recoil upon the hull of the water which the screw acts on, would make the apparent slip about 22 per cent.

5. The screw at the bow, using the same horse power as the screw at the stern for equal revolutions, propels the boat slower than the screw at the stern by an amount practically equal to the equivalent of the extra resistance due to the increase of the velocity of the boat by an amount equal to the velocity of slip of the screw.

6. By calculations based upon the accepted relations between the slip of the screw and the velocity of a boat, it appears that, in order for the double screws to produce the same speed as a single screw of the same diameter at the stern, the slip of the latter must be to the former in the ratio of 18 to 11⅝, and therefore the cause of the extra power consumed by the two screws, as compared to the one screw, is the fact that the slips are as 18 to 12·6, instead of as 18 to 11⅝. The details of this calculation are given in the body of the paper.

The coal used in the tests contained about 89 per cent. of combustible, and the total heat of combustion was about 13,000 heat units per pound.

In order to eliminate the influence of the tide in

TABLE III.

	Orange. Pounds above Atmosphere.		Bergen. Pounds above Atmosphere.	
	120 Mile Run.	Ferry Service.	120 Mile Run.	Ferry Service.
Pressures.				
Average boiler pressure, lb	17	32	114	140
" pressure during admission	16	31	105	100
" back pressure	..	4½	..	3
" vacuum pressure	..	27 in	..	27 in.
Temperatures.				
Feedwater, deg	98	..	118	..
Uptake, "	500	..	750	..
Top of stack "	435	..	650	..
Indicated Horse Power.				
I. H. P., including all pumps	400	310	..	..
I. H. P., not including "	..	..	665	650
I. H. P., feed pump	..	..	9	..
I. H. P., circulating pump	..	..	3	..
I. H. P., bilge "	.	..	1½	..
Total Weights.				
Bituminous coal per hour, lb	1,560*	..	1,580*	..
Percentage of ashes	11	..	7·87	..
Feedwater per hour for all purposes	13,487	..	14,511	..
Feedwater per hour for pumps, etc.	.	..	2,358	..
Feedwater per hour for steering engines, lb	..	150	..	150
Efficiency of Boilers.				
Evaporation at actual pressure and temperature of feed per pound of coal	8·65	..	9·2	8·42
Evaporation from and at 212 deg. per pound of combustible	11·00	..	11·40	..
Efficiency of Engine.				
Water for all purposes per hour per I. H. P	27	25	21·8	22·9
Water, main engines only, per hour per I. H. P.	..	..	18·3	..
Water, feed, and circulating pumps, etc., per hour per I. H. P.	..	.	160 condensing	130 non-condensing
Theoretical water per hour per I. H. P. Calculated from card	20	.	13·2	.

* These amounts are estimated from the feedwater consumed, by use of the figures for evaporation per pound of coal, as determined from the boiler tests.

TABLE IV.—SUMMARY SPEED DETERMINATIONS OF BERGEN.

Conditions.	Revolutions per Minute.	Horse Power.	Observed Still-Water or True Speed, Statute Miles per Hour.	Slip Per Centum.	Estimated Speeds. From a Speed at 145 Revolutions by Law of Cubes.	From Augmented Surface. $V=\sqrt[3]{\frac{21,300 \text{ H. P.}}{\text{Aug. Surf.}}}$	From Apparent Slip.
	1	2	3	4	5	6	7
2 screws in use	142	662	11·9	16·4	12·37	14·19	11·8
" "	145	700	12·62	12·6	12·60	14·57	13·4
" "	162	1007	14·6	11·0	14·30	16·13	16·2
" "	114	334	10·5	10·?	10·50	11·27	11·6
" "	71	97	6·4	10·?	6·00	7·45	7·8
1 screw at stern	145	458	11·96	18·2	11·96	12·5	12·7
" "	163	664	13·42	17·7	13·67	14·32	14·4
" "	83	93	6·98	16·0	7·30	7·36	7·8
1 screw at bow	145	461	11·28	22·3*	..	11·99	13·0

* Assumed to be 18 per cent. for calculation of Column 7.

TABLE V.—SPEED OF PADDLE WHEEL BOAT ORANGE.

Revolution.	Horse Power.	Observed True Speed, Statute Miles.	Speed calculated from Aug. Surface. $V=\sqrt[3]{\frac{18,000 \text{ H. P.}}{\text{Aug. Surf.}}}$	Apparent Slip Percentage.	Speed estimate by Law of Cubes. Statute Miles.
22·9	400	11½	12·1	26	..
24·6	642	..	..	26	12·6

making tests on the Bergen, using one screw only, a tide curve was plotted. The observations were made from two boats anchored at the north and south extremities of the two mile course over which the boat was tried. To correct the observed speeds of the vessel, the mean curves *c* and *d* we reused. The results are shown in Table IV.

The total feed to the boilers was measured through a calibrated meter, and the steam consumption of the main engines, in the case of the Bergen, was determined by subtracting from this total the estimated consumption of the feed bilge and circulating pump cards. The feed pump is a duplex pump 12 inches by 12 inches by 4½ inches, running at 55 revolutions per minute, and indicating 9 horse power. The bilge pump is also a duplex pump 12 inches by 12 inches by 5 inches, running 48 revolutions per minute and indicating 1½ horse power. The circulating pump is of similar type, 12 inches by 13 inches by 14 inches, running at 22 revolutions per minute. An allowance was in each case made for condensation in the cylinders of these pumps.

A comparison of the figures given in the table shows that in ferry service the Bergen is 5 per cent. more efficient than the Orange, and there can be little doubt that a prolonged experience will show a considerable balance financially in favor of the Bergen.

In addition to the foregoing we give additional engravings of the Bergen and particulars as given in the SCIENTIFIC AMERICAN:

We illustrate the new ferryboat Bergen, launched from Thomas C. Marvel & Son's ship yard at Newburg, New York, and now in service on the ferries of the Hoboken Land and Improvement Company, of New Jersey, between New York and Hoboken.

This boat represents a new type of vessel, and if the anticipations are realized, she will effect a revolution in the ferry service of this vicinity. She is a double-ended boat, provided with a screw at each end. The shaft runs the entire length of the boat, so that the screws are rotated together. A single compound engine is provided for driving them. Several new points of advantage are obtained by the adoption of this type of vessel. The engines and boilers are all under the deck, so that much room is saved in the central trunk. In the new vessel this portion is about two-thirds the length of the corresponding structure in boats of the present type of side wheeler, and two feet narrower. In order to still further utilize the space-saving possibilities of the last named feature of the system, the smoke stack from the main deck to the hurricane deck is elliptical in section, the long axis being parallel with the keel of the boat.

The effect of these changes gives 20 per cent. more room for trucks and carriages. By abolishing side wheels the large paddle-wheel boxes which ordinarily encroach upon the cabin spaces on either side of the paddle boats are done away with, and unincumbered cabins are provided. In this way the capacity for passengers is increased 35 per cent.

But it is not only in these respects that the boat is an improvement on the old system. It has been found that ferry slips can be cleared of ice very advantageously by the use of a tug boat. This ice often forms to a very great depth, and paddle wheels are found quite inefficient in coping with it. A tug boat is driven into the slip until all the ice from its stern outward is expelled; it is then withdrawn and backed into the slip until the rest of the ice has been driven out. This has been found to be a most effective way of disposing of the trouble. Paddle wheels only drive ice twenty feet away, but the screw has a greater range of action. The new boat, with a screw at each end, both working in the same direction, has a double effect. The front screw creates powerful water currents which carry the ice toward the stern, and the after screw supplements the work and sends the ice out far into the stream.

In order to be adapted to the requirements, the model presents certain peculiarities. A very clean run fore and aft is requisite, in order to give good water for the screws to work in, so that below the water line her model is very fine. On account of its overhanging guards and the crowds of people that it carries, and which are liable to crowd always toward the front end, a high initial stability is required in a ferryboat. The hull, therefore, as it rises swells out, so that for some distance above and below the water line it is characterized by exactly the opposite lines of those mentioned. The bow and stern, as she floats, appear very full, while the model, further down, is a sharp one.

In general dimensions she is 200 feet in length, and 62 feet across her guards in extreme width. Her hull is 32 feet wide and 17 feet deep. With engines and all in place, and her load of passengers on board, she draws from 9½ feet to 10 feet. Her boilers, which are 8 feet in diameter and 23 feet long, are of tubular type, and work at 160 lb. pressure. She has two furnaces, each one 3 feet 4 inches by 6 feet 9 inches. They burn about 14 lb. of coal per square foot per hour. Her engine is a triple expansion one. It has one 18½ inch, one 27 inch, and one 42 inch cylinder, all of 24 inch stroke. The crank pins are of uniform diameter, because the engine will have to work as much in one direction as in the other. The shaft is from 8¼ to 8¾ inches in diameter. The screws are 8 feet in diameter, and 9¼ feet pitch. In making them, both faces were made exactly alike, because they have to be worked first in one direction and then in the other. She is built of steel throughout.

In one of his papers read before the Naval Institute, Lieut. Zalinsky alluded to the use of ferryboats for harbor defense, stating that pneumatic dynamite guns might be mounted on them, and that such vessels would do good service against a hostile fleet. This new ferryboat emphasizes this suggestion. It has no paddle wheels to be damaged by shots or ramming. As will be observed, all its machinery is under the deck. By the addition of ballast it could be submerged still deeper, so as to bring most of the machinery under the water line. Coal bunkers could be introduced on each side of the engine and boilers, to further protect them, while the guards could be used for the suspension of torpedo nets. The space included between the guards and the sides could be lined with resisting material as a species of armor.

The practicability of making use of the ferryboat type as a war vessel was abundantly proved in the late rebellion, when so many were called into active service. This new vessel would certainly be much more efficient if impressed into service than the old fashioned paddle wheel type. With our present defenseless seaboard, such considerations are not wholly without weight, and the advantage of having a class of boats at our disposal that could be quickly converted into an efficient river fleet is not to be underestimated. Of course this feature was not borne in mind in the construction of the Bergen, the chief advantages sought for being greater room, higher speed, a more efficient and powerful vessel with which to cope with the ice blockade in the river and slip, and more commodious, airy, and handsome saloons, extending unbroken through the entire length of the boat.

To locate the deficient working of machinery with numerous points of friction causes often both annoyance and waste of time, owing to the surrounding noise interfering with the observation of the sound to be isolated. The *Revue Industrielle* mentions as an effective and exceedingly simple means of overcoming this difficulty the use of a rubber tube about a meter long, one end of which is placed in the ear and the other passed over the suspected spots. The vibrations from all other parts than the one covered being excluded, it is an easy matter to locate jarring noise, and when found, to observe the intensity and periodicity with which it occurs.

[Continued from SUPPLEMENT, No. 773, page 12348.]

THE DEVELOPMENT OF THE MARINE ENGINE, AND THE PROGRESS MADE IN MARINE ENGINEERING DURING THE PAST FIFTEEN YEARS.*

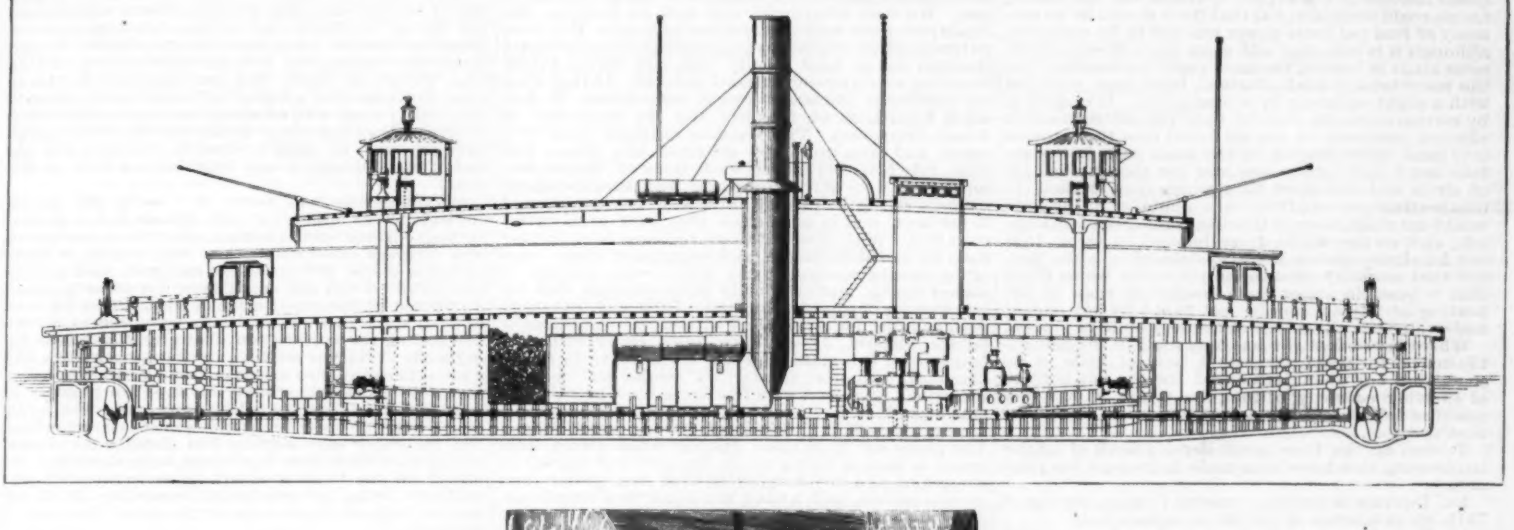
By A. E. SEATON, M.I.C.E., M.I.M.E., M. Council, I.N.A.

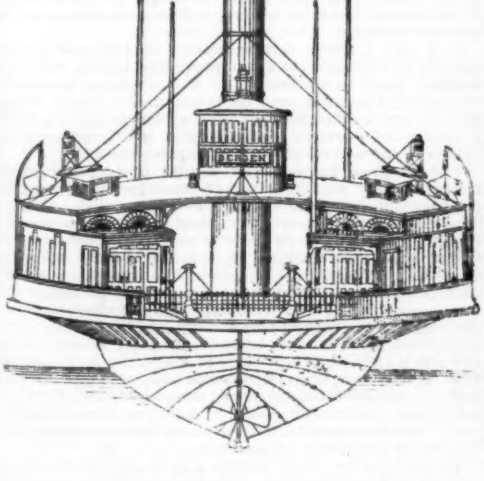
MR. THORNYCROFT,† now so well known as the designer and builder of steam launches, and, later, of torpedo boats, soon had to give up non-condensing engines and condense the steam so as to get fresh water for feeding the locomotive boilers he used. The loss of means of draught in the escape steam caused him to substitute artificial sources of air supply, and he found that by forcing air under the grates he could get an increase of steam supply over that given formerly by the steam blast. The pressure of air was increased from the half inch to as much as six inches of water, corresponding to that of the fiercest draught of an express locomotive; the supply of steam was excellent, and the speed obtained with a steam launch of considerable size and torpedo boats larger still was very high, and was at the time considered marvelous. The means whereby these improved results were got were in themselves simple and inexpensive. The compartment containing the boilers was made airtight, and into it was forced a supply of air from the deck by means of one or more fans of the ordinary type, driven by an independent engine. The simplicity of these means, and the success attending the experiments, led our naval engineers in 1880 to adopt them on a large scale in some cruisers of the Leander class, the result being that with precisely the same engines and boilers, and with only the addition of the forced draught arrangement, a considerable increase of speed was achieved. Since that date, similar forced draught arrangements have been fitted to all the new ships built for the British navy, and the example thus set has been followed by the engineers of other countries.

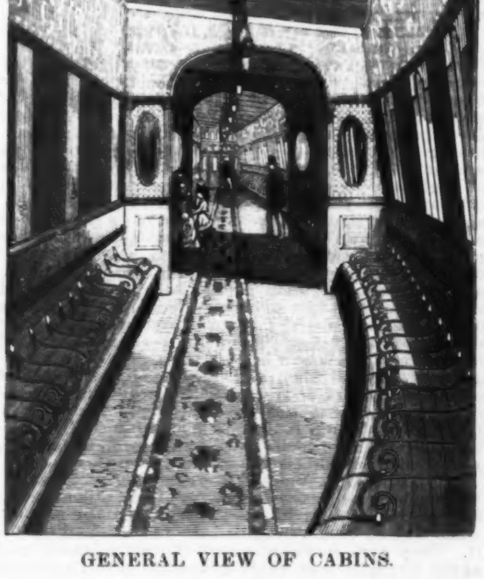
As an illustration of what can be done in this way, it is sufficient to instance the case of the first-class belted cruisers of the Immortalité class. When working under natural draught, the power to be indicated was 5,500 horses, and on the trial trip as much as 6,000 horse power was developed. With forced draught, due to an air pressure equal to two inches of water, it was expected that 8,500 horses would be developed by the engines; but as a matter of fact, on the trial trip and under these conditions over 9,000 horse power was obtained, and the speed was raised from 16½ knots to 19 knots. At the present time, speeds of 20 knots per hour are being realized in her Majesty's navy with engines and boilers of such a size as ten years ago would have been deemed sufficient for a speed of only fifteen knots. It is, however, I regret to say, a fact that now very considerable difficulty is being experienced by those having to do with machinery for the English navy in running continuously under forced draught without more or less trouble with the boilers. This is not, in my opinion, due to the system, but to the want of suitable provision in the boiler design for the conditions under which they have to work when being pressed to the utmost. It is, in fact, a little error of judgment on the part of the authorities into which they have been led by the perfect success of their previous efforts in the same direction; and just as the

* A paper read before the Iron and Steel Institute, New York meeting, October, 1890.

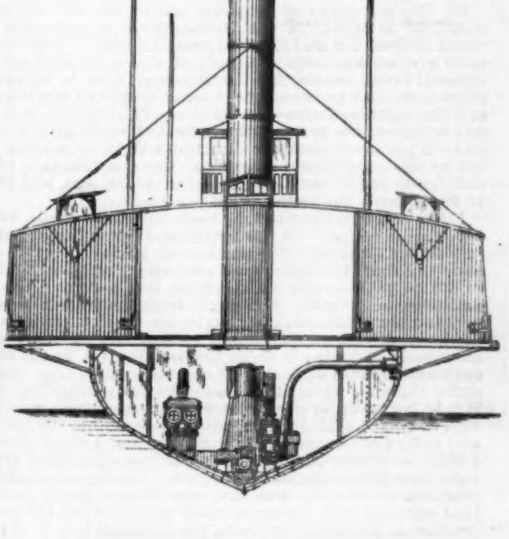
† I have given Mr. Thornycroft the credit of the modern application of forced or artificial draught, but the fact is that the first attempt in this direction was made by Ericsson in 1829 to the steamer Victory, commanded by Sir John Ross, and, strange to say, he enters in his log that "the boiler still continued to leak, although we had put dung and potatoes in it, as directed by the engineers."







GENERAL VIEW OF CABINS.



THE DOUBLE SCREW FERRYBOAT BERGEN—NEW YORK AND HOBOKEN FERRY.

locomotive engineer of to-day is dependent on, and has the utmost faith in, the forced draught by which he gets express speeds, so the marine engineer will get over his difficulties as the locomotive engineer did, so that in the near future we shall see ships whose boilers are worked under forced draught with perfect safety and confidence doing express speeds.

In the days of natural draught and compound engines, 10 horse power per square foot of grate was thought to be a good output; with the introduction of the triple engine and higher pressures a natural draught would give 14 to 15 horse power per square foot of grate; and the modern forced draught now in use in large ships enables us to get 20 horse power per square foot of grate; and in smaller boats, where the air pressure in the stokeholes has been raised above two inches, even higher results have been reached.

With the success of the principle of forced draught came the usual number of enterprising inventors with their inventions, some of them good, some of them not worthy of notice, but all of them more or less misunderstood so far as the objects aimed at and the end to be attained were concerned. As a means to a particular end, forced draught has been a success; as a means to the several ends had in view by experimenters, it has not been a success. When the consumption of a larger amount of fuel per square foot of grate with a consequent increase in the supply of steam was the object, no one could complain; but that there should be an economy of fuel per horse power was not to be expected, although it is true that with some kinds of coal, and in some kinds of boilers, the more rapid combustion, and the more intense heat obtained, have been attended with a slight economy in consumption. It is claimed by certain inventors that by their patents economy is effected, inasmuch as the air forced into the furnaces is to some extent heated by the waste gases in the uptake and funnel; but seeing how low the specific heat of air is and the short time which it is exposed to the heating process, it is very doubtful if the gain would outweigh some of the disadvantages of the system, and, on the whole, I am inclined to think that our Admiralty system of closed stokeholes is the best, and that economy must be sought in the better firing that is possible under these conditions than to the heating of the air supply—not that I by any means undervalue the advantage of the regenerative process.

Where forced draught has been used in the mercantile marine for speed purposes, I hear of little or no complaint, but when introduced for the sole purpose of effecting economy of fuel, the praise is of a very qualified nature, and the complaints, when made, are unmistakable.

To sum up, the three great *developments* of marine engineering that have been made in the past ten years are:

1st. Increase in working pressure from an average of 75 lb. to an average of 150 lb. per square inch.

2d. The adoption of the triple and quadruple expansion system; so as to utilize steam of this high pressure efficiently.

3d. The adoption of artificial means for obtaining sufficient draught for the consumption of coal, and, when desired, for an increased consumption of coal, so as to give an augmented supply of steam without additional boiler capacity; with the result that in naval ships now with practically the same weight of machinery the indicated horse power is nearly doubled, and, in the mercantile marine, the indicated horse power is 50 to 75 per cent. more for the same weight of machinery as was used fifteen years ago, the consumption of coal being 20 per cent. less than ten years ago, and 25 to 30 per cent. less than fifteen years ago.

I now come to the *progress* that has been made by the marine engineer in the design and manufacture of machinery, whereby the engine of to-day, notwithstanding that it is lighter and even cheaper than that of fifteen years ago, is worked with less wear and tear and fewer accidents. Although, from the tremendous demand made for sea-going engineers (so that the supply has not been all that could be desired), the marine machinery of to-day is probably not in the hands of such experienced and skillful men as then, it does not suffer thereby, while at the end of twelve months' work it is in better order now than was the case fifteen years ago. I do not wish by any means to disparage the skill and ability of our sea-going engineers, but I think that I shall be supported when I say that younger faces are to be seen in the engine rooms to-day taking important positions there than was the case fifteen years ago; that whereas then a natural taste and aptitude for the profession was a *sine qua non* for entrance into it, it is now flooded to a great extent by young men who simply look on it as being more lucrative than some other professions and trades, to which admittance is easy, have now become.

That constant complaint of hot bearings has practically become a thing of the past is partly due to improved construction and better design, consequent on a better understanding of first principles; but good white metal has done almost more, as it has been found to be a panacea for the evil where it has existed for years in the older engines; and whereas formerly it was only war ships and those of the best mail ship companies that indulged in the luxury of white metal, now the meanest of steamships has, as a rule, this metal in the main bearings and crank-pin brasses, as a matter of economy; for a hot bearing always means an expensive bearing, both in coal consumption and in wear and tear and renewals. The increased length of life of crank-shafts is due to the absence of hot bearings, as well as to the lighter strains put upon them. It is white metal that has permitted of the high number of revolutions per minute that I have already pointed out as being one of the conditions of high speed in ships.

I would also express the opinion that the crank-shaft of to-day is better made and of better material than was the case fifteen years ago. Improved methods of manufacture of iron forgings, and the improved steel which you, gentlemen, give us, admit of a better surface, and the well made and heavy lathes of the present day can do the work not only cheaper but truer than was the case then. It is to be hoped that the combination of the crank-shaft makers in England, whereby the price is kept up, will act in maintaining the quality, and, if, possible, raising it beyond what it was when competition was so severe.

In the construction of the modern marine engine the most marked feature of change is the quantity of steel castings introduced, sometimes in the place of forgings, sometimes in the place of iron castings, and sometimes in the place of brass castings. I ventured more than twenty years ago, when I was a student of engineering, to predict that the time would come when we should get steel cast into the various forms we required, and that, with the introduction of such a metal, cast iron would gradually disappear from the marine engine. My prophecy has been fulfilled in a sense sooner than I anticipated, but cast iron has not yet been driven from the field so rapidly as might have been expected after the introduction of steel castings. The fact is, that you, gentlemen, have not yet learned the full secret of success; and I do not say this reproachfully, for so many of your members have worked energetically at the problem and have improved in your productions in such a comparatively short time, that you deserve praise rather than censure. We engineers do complain—sometimes very savagely—of the delays we experience in obtaining steel castings, and of the loss to us when, after machining for days, we open up such faulty places as to necessitate the condemnation of the castings; but in our calmer moments we are fain to admit that our wonder should rather be, not that bad castings are made, but that we sometimes get good ones. Ten years ago my firm commenced using steel castings in lieu of iron ones, for such parts as were subject to shock, and were of so plain a design as to be easily cast. We then substituted cast steel for forgings the strain per square inch on which was very light. For these purposes all we required was a material whose ultimate strength was at least twenty tons, and which, before breaking, would stretch at least 5 per cent. At that time our particular sources of supply were Messrs. W. Jessop & Sons, Limited, Sheffield, and Mr. Aesthower, of Annen (Germany). The German castings were very sound, and came up to the standard laid down, but went very little beyond it; while those of Messrs. Jessop & Sons were only fairly sound, but they possessed a tensile strength of thirty tons, with an elongation of 20 per cent., and in some cases they were even better than this. With these latter we ventured to go further than we had done before, and we made of them some of the smaller working parts, which were subject to higher strains, and eventually the connecting rods for two engines of considerable size. These rods have now been running for seven years without showing signs of failure. Messrs. Jessop have made crank shafts of large size of this material, even, I believe, to 15 inches diameter, with most satisfactory results, and the castings when machined were free from blow-holes, draw-cracks, and even sponginess, while they had all the appearance, when finished, of having been forged. The pieces cut from these castings when tested were found to have as high a tensile strength and as good an elongation as a steel forging, so that, from *prima facie* considerations, such a shaft was equal to a forged one, and I am not aware that experience has proved the contrary. To-day we are constructing in the works of my firm (Earle's Shipbuilding and Engineering Co., Ltd., Hull, England) engines of 12,000 horse power, in which the foundations, the whole of the columns, the pistons, the thrust-blocks and collars, the eccentric straps, the cylinder and valve-box covers, and many other of the minor details, are made of cast steel. The saving of weight is such that, taking *one* of these engines—they are twin screws—and half the boilers, that is to say, taking a set of machinery of 6,000 horse power, its weight is 560 tons, against [illegible] tons, the weight of a set of engines, boilers, etc., of 6,000 horse power made in 1870, and 1,000 tons, that of compound engines in 1875, and which at that time were deemed to be the lightest of the kind, and were run at very nearly the same number of revolutions as the modern one. The ship for which our engines are intended is being built by us, and has a cast steel stem, a cast steel stern post, a cast steel rudder, and cast steel propeller brackets, besides other cast steel fittings for gun and other purposes throughout the vessel. The fact is that our demand for steel castings is now large, and is, moreover, a progressive one; and when you, gentlemen, by means of aluminum, nickel, or any other "doctor," will give us sound castings that we can rely upon, so that we may not throw away our money by machining, only to discover defects by which the castings are condemned, we will prove even better customers than we are now.

In 1875, Messrs. Vickers, Sons & Co., of Sheffield, were making very large crank shafts and other shafts; and in the Atlantic it was getting to be the custom, when a shaft broke, to substitute one of Vickers' for it. They were, however, a very expensive luxury; and as the wrought iron shaft generally gave its owners timely warning of when it was going to break, and the steel one didn't, the latter was treated as untrustworthy, and was not adopted by the majority of engineers or shipowners. To-day, instead of there being only one firm that can make these shafts, we have a dozen, and at least half a dozen of these whose reputation stands in the first rank. The Siemens furnace now produces steel for shaft purposes at as low a rate as ruled for the Bessemer in 1875. The substitution of hydraulic presses for steam hammers, too, has not only improved the quality of these forgings, but most undoubtedly has been the means of reducing their price, and we now have steel crank shafts, steel propeller shafts, steel piston and connecting rods—in fact, every forging of steel in a war ship and in the highest class of mail steamers, and throughout the mercantile marine there is a general tendency to substitute this superior metal for the inferior. In H. B. M. navy the shafting is made in accordance with the plan introduced by myself in 1872, whereby, by making the shafts hollow, a considerable reduction is effected in weight, with an exceedingly small reduction in strength. For example, a shaft 10¼ inches external diameter, with a hole 5 inches diameter through it, is equal in strength to a solid 10 inch one, but its weight is only a little over three-fourths that of the solid one. I need hardly say, however, that the difference in cost is considerable; in fact, there is the added cost of boring out the hole. Siemens steel is now very little dearer than ordinary crown quality iron, and no dearer than the best qualities of iron required by marine engineers, so that all the bolts, studs, nuts, and pins used by my firm are of steel.

The general effect of the substitution of steel for iron in the construction of a marine engine is to save weight, and at the same time to have a stronger machine. The modulus of elasticity being with steel only about the same as that of iron, renders it impossible to make any very substantial decrease in scantlings of many of the parts, but generally such a decrease is effected, and so the modern engine, composed almost entirely of steel, is lighter than one of iron. The collapse in the City of Paris (s. s.) has no doubt shaken the minds of some as to the use of steel castings. But I think it has been proved most conclusively at the trial that the accident was not in any way due to the steel castings, and that they did give way is perhaps not to be wondered at under the circumstances. At the same time I am of opinion that it is unwise, with our present knowledge of the trade, to cast columns hollow, *i. e.*, cored throughout their length.

It is, of course, possible to do this successfully, but the risk of it is great, and the liability to obscure cracks and unseen faults must be also great. At all events, my experience with the material has taught me to avoid such a form as far as possible, and certainly never to make an important part like a column of an engine a hollow casting, more especially with a thin section.

I do not suppose it is of equal interest to your Institute, but it is nevertheless a fact that very marked improvements have been made in the manufacture of bronze castings and also of bronze forgings. Fifteen years ago a gun metal casting, with an ultimate strength of fifteen tons per square inch and an elongation of five per cent. was considered very satisfactory. But to-day we have the various bronzes, such as phosphor bronze, manganese bronze, Stone's bronze, aluminum bronze, etc., etc., having strengths varying from twenty to thirty tons per square inch, and in some instances even a higher ultimate tensile strength than thirty tons, with an elongation approaching that of steel. Forgings made from some of these metals have proved to be equal to steel in strength, and the cost of these bronzes is very little beyond that of gun metal.

Advantage has been taken of this by the marine engineer to use forgings of these metals in lieu of brass castings, drawn bars in lieu of either brass castings or iron forgings cased with brass, and, finally, to make propeller blades of it instead of cast iron, steel, or even gun metal. I will not detail here the gains in speed attributed to the substitution of the bronzes for steel or iron, but content myself with accepting as a fact, and stating the same to you, that propeller blades being made of thinner sections, having keener edges and a smoother skin, give a better result than the heavy cast iron blades did, or than the steel can possibly do when pitted and roughened by sea water. The action of sea water on these bronzes is sometimes capricious, but generally only slight. The English Admiralty, acting upon their own experience, have discarded the use of all the bronzes except phosphor bronze and ordinary bronze or gun metal (consisting of 87 per cent. of copper, 8 per cent. of tin and 5 per cent. of spelter).

So far this distrust of other bronzes is not shared by the mercantile marine. I have, however, seen some remarkable failures with certain of the bronzes. For example, a new propeller fresh from the makers was found, after lying on a wharf for a few weeks, subjected to severe frost, to be cracked so seriously as to be utterly useless.

It is also a thing not unknown to the mercantile marine to lose one or more propeller blades without notice. And as indicative of the direction in which engineering opinion may be tending, the latest thing in propeller blades we hear of is a bronze casting with a cast steel core, or perhaps you, gentlemen, would prefer to say a steel casting with a bronze skin.

The progress in propeller design and construction has been very slight, although each month seems to produce a new inventor with a new propeller—at least new to the inventor—that is going to revolutionize the shipping world; but in spite of newspaper paragraphs full of hope and promise, if, alas! somewhat showing great want of scientific and technical knowledge of the first principles of propulsion, the screw propeller remains without a rival. Its shape has not altered much, although the very bad forms have gradually died out; and although much has been claimed for those having the pitch varying in all kinds of ways, the fact remains that in the navy, as in the mercantile marine, those who have given most thought to the subject, and most observation, prefer a propeller of uniform pitch throughout. In other words, it is desired that its acting surface shall be part of a true helix.

Propulsion by twin screws has many practical advantages, but it is chiefly now adopted from considerations of safety, inasmuch as a ship with two screws is less liable to have both injured at the same time, and, therefore, her whole propelling apparatus broken down, than one with the single screw; and, in case of accident to the steering gear, she can be steered by varying the revolutions of the engines. Moreover, a smaller propeller is required for each of the twin screw engines than that needed for a single engine of same power; hence in the case of a deep draught ship, owing to the deep immersion, the twin screws work with a higher efficiency, and in the case of a shallow draught vessel the same holds good, inasmuch as they are thoroughly immersed when the single screw of the same power would be partly out of the water.

The adoption of steel boilers naturally suggested the advisability of using fresh water, not so much on grounds of cleanliness as of avoiding corrosion. This bugbear, however, has proved, like many others, not to exist. Experience has shown that the steel boiler does not corrode any more rapidly than the iron one; and, as a matter of fact, the life of boilers made of steel is likely to be very considerably longer than that of iron ones. The first steel boilers made by my firm twelve years ago are working at their original pressure, under the inspection of the British Board of Trade and Lloyds, and they are likely to continue to do so for many years yet to come. I am, of course, aware, and would remind you, that this increase of length of life is due in no small degree to the better treatment accorded to them. The use of zinc in the form of cast slabs or rolled sheets, especially in the earlier months of their life, has been the means of preserving boilers in a way not known before; and the general practice of causing the feed water to enter the boiler at a comparatively high temperature has also tended to increase their durability; but I repeat that under the same conditions the steel boiler shows no tendency to corrode any faster than the iron one, and the steel boiler has,

besides, the advantage over the iron one of not developing blisters in the internal parts exposed to flame, so that the patching of furnaces is a comparatively rare thing nowadays.

The demand for fresh water for feed purposes has been emphasized since the use of steam of 150 lb. pressure and upward, especially for vessels making long voyages. It goes without saying that the power to generate steam in any boiler must decrease very quickly as the scale on the heating surface increases, and also that the temperature necessary to produce steam of a certain pressure gets higher as the density of the water increases. Hence, when the waste is made up with sea water in boilers whose working pressure is 150 lb. and upward, the speed of the ship increases toward the end of the voyage, and, what is worse, the boilers often give out, and require extensive and costly repairs.

The consumption of coal is also very much higher than it would be if the boilers were kept clean throughout. Attempts to remedy this evil were first made by carrying a supply of fresh water in the double bottoms of the ships or in tanks specially provided for the same. This expedient helped matters, but was not a perfect success, as the water supply often contained large quantities of sulphate and carbonate of lime, which formed a hard scale, and which, together with the sea water, made a worse scale than the sea water itself—that is, worse to deal with afterward. This water also cost money, and what was more objectionable, the carrying of it often reduced the quantity of cargo. Other attempts were made to supply fresh feed to the boilers by means of the donkey boiler, the steam from it being condensed in the condenser and pumped into the main boilers. The donkey boiler, however, became then a sufferer. As a rule, they are not easily cleaned, so that it was only a matter of time for this source of supply to fail, and to be not available for some days. Finally, Mr. James Weir, of Glasgow, whose inventions, especially for improving the efficiency of the boiler, are of wide repute, introduced his now well known evaporators, which consist really of a small horizontal boiler, ingeniously contrived, so as to be easily taken to pieces and cleaned, and the water in it evaporated by the steam from the main boilers passing through a set of tubes placed in its bottom. The steam generated in this boiler is admitted to the low pressure valve box, so that there is no loss of energy, and the water condensed in it is, of course, returned to the main boilers. The extra supply from it is still obtained at the expense of coal, but without any risk of injury, and at a more economical rate than was the case when a donkey boiler was employed. Other engineers have designed and patented apparatuses to do the same work, and it is now getting to be a universal practice for all oceangoing steamers to have feed evaporators. Mr. Weir's feed heater, whereby the feed water, before entering the boiler, is heated up very nearly to boiling point by means of the waste water and steam from the low pressure valve box of a compound engine, is another most useful appliance, and was introduced in 1878. It is also becoming every day more and more used, and, in conjunction with Mr. Weir's special feed pumps, is a very desirable thing to have in every steamship, as not only is the feed water delivered to the boiler warm, but so regularly, and with such very slight risk of cessation, as to render the engineer on watch quite easy on the score of feed supply.

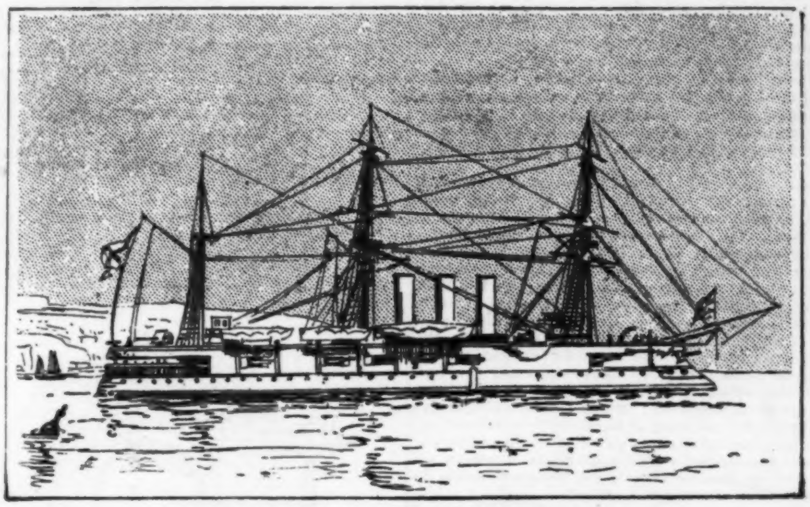
It is claimed for many feed heaters that they are the means of effecting an economy ranging as high as 15 per cent. I mean marine feed heaters, where the heating is done by steam, and not by waste gases in the uptake. It is not obvious how there can be any saving at all, and in my opinion the tens and fifteens per cent. are apocryphal. That steam is better maintained in the boilers with such appliances is undoubted, and that in cases where difficulty has been experienced in keeping up the full pressure, the fitting of a feed heater has been the means of doing it; so that there must be some saving, although in the nature of "robbing Peter to pay Paul." The fact is, the warm feed assists rather than retards the circulation, and the saving is more in that direction than in any other.

Improvements have been made in the engine room and boiler room of nearly every steamer in the direction of making the work lighter both at sea and in port, and the occupation of the engineer not so severe. Ventilation has been better understood and practiced. The covering of the hot parts by non-conducting material has been extended, and the substitution of superior non-conductors, such as fossil meal and asbestos compositions, has unquestionably effected a saving. Steam starting gears, too, have during the last fifteen years been introduced into all classes of ships, and even the smallest of them now may be found provided with this appliance for the more rapid handling of the engines. Steam turning gears and steam ash hoists have been also introduced, and all such fittings must naturally tend to the more economical working of the vessel.

In conclusion, I would beg to summarize by saying that in fifteen years the speed of steamships carrying passengers has been increased from 30 to 40 per cent.; the consumption of coal per horse power has been decreased from 20 to 30 per cent., or say an average of 25 per cent.; the cost of a horse power has been decreased by almost a similar amount, and in some cases is but a half of what it was in 1875; and the safety, comfort, and convenience of the traveling public have been enhanced instead of sacrificed. These successes are largely due to the members of the Iron and Steel Institute, and the balance is due to the skill and ability of marine engineers, but it must not be forgotten that the whole has been backed by the enterprise and sagacity of the shipowners.

THE RUSSIAN CRUISER PAMIAT AZOVA.

THE Russian cruiser Pamiat Azova (Memory of Azoff), a fine specimen of Russian naval architecture, which has only lately been completed, arrived in Plymouth Sound recently *en route* for Malta, Sevastopol, Vladivostock. Her three funnels give her a somewhat uncommon appearance. Prince George, the Czar's second son, is serving as a sub-lieutenant on board her. She has a formidable ram, and is armed with two 18½ ton and twelve or thirteen 6 in. Obouchkoff breech-loading cannon, besides quick-firing and machine guns and torpedoes. Her speed is estimated to be eighteen knots. She is fitted with the most "up-to-date" appliances for lowering boats, electric lighting, etc., while the number of her cabins and the comfortable and useful fittings in them is far in advance of many British men-of-war of much greater tonnage. Her name is in commemoration of the Azoff, a Russian man-of-war which greatly distinguished herself in the battle of Navarino.—*London Daily Graphic.*



THE RUSSIAN CRUISER PAMIAT AZOVA.

IMPROVED GRATE BAR.

THE tubular smoke-consuming chilled-faced firebar manufactured by Messrs. Caddy & Co., of Nottingham, is already extensively in use in land boilers, and now being largely adopted by steamship owners. From the sectional view of it (Fig. 1), it will be seen that an oblong tube of wrought iron extends throughout the bar. This distinguishing feature accomplishes two important purposes. It gives immense strength to the bar, and carries air to the back of the bridge, where, coming in contact with the unconsumed gases, it provides oxygen for their ignition. Smoke is thereby reduced to a minimum, and the greatest amount of heat is obtained from the coal. The breadth of the bar is only one inch, being less than most of the ordinary

FIG. 1.—SECTION.

plain ones in general use. To increase its durability the best mixture of metal is used, and, being cast face down, that part which, when in use, is exposed to the heat of the fire is the heaviest and solidest metal, all scum and imperfections rising to the top or web of the bar. The face, which is slightly rounded, is also chilled to the depth of nearly three-quarters of an inch, and made so hard that in some cases it is years before it is touched by the fire. By the introduction of heated air at the back of the bridge, without robbing the grate of any air that ought to pass through it in the ordinary way, economical consumption of fuel is effected. By the smoothness of the chilled face and the temperature of the bar being reduced by the passage of air through it, clinkering is effectually prevented.

This type of bar possesses the qualities necessary for the complete and economical combustion of fuel. Its

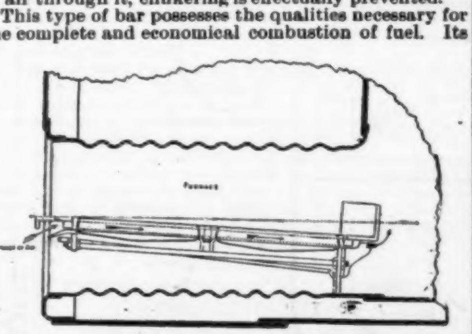


FIG. 2.—ARRANGEMENT OF MARINE BOILERS.

lifetime is equal to that of three sets of ordinary bars, and that not alone because of the cooling influence of the air passage, but largely on account of the presence of the through wrought iron tube preventing warping, and even, in the case of fracture, preventing the bar dropping below the level of the grate, as a fractured or burnt bar of the ordinary kind would inevitably do.—*Marine Engineer.*

FUEL GAS AND SOME OF ITS APPLICATIONS.*

By BURDETT LOOMIS, Hartford, Conn.

THE advantages of gaseous fuel have been too fully set forth during the past few years to need recapitulation. Papers, arguments, and editorials have been issued, in a more or less general way, that would make volumes. Systems have found zealous advocates, and promises of results made, that have sounded strangely in the ears of old fashioned gas makers, have been born of theory, and have died in the earliest throes of trial; while in some few instances success has demonstrated the value of practical effort. With few exceptions, however, everything attempted or accomplished has tended toward the one end—the realization of more perfect results than we can obtain with the direct use of solid fuels; and there are to-day few to dispute the coming supremacy and general use of gaseous fuel.

It is not assumed that the solid fuels will be wholly superseded; such an assumption would be folly, as there are circumstances in which solid fuels must continue in use, from necessity or economy. These, however, are few, and can almost be named in a breath; while the purposes for which the gaseous fuel is not only cheapest, but best, are so many as almost to defy enumeration. Wherever constant high flame temperature is necessary, the gaseous form must find precedence, while its easy carriage to long distances and its attainment of maximum temperature almost instantaneously with ignition give it a leverage that is scarcely covered by that easy term—convenience.

The discovery and application of natural gas has not only borne the weightiest of testimony on behalf of the general necessity for fuel gas in nearly all fields, but it has done more. Its wide scope of service, from the great establishments wherein thousands use it constantly to the cottage where it saves countless steps for the housewife, has demonstrated the necessity for a gas of general application, that will fulfill all the demands of the manufacturer, and meet the wants of the domestic user. The fuel gas that is to score a wide success must fill these conditions. For a gas that will not, the field is limited.

In the manufacture of a fuel gas, then, it is obvious that certain conditions are primarily necessary.

As concerns the apparatus to be used, these are:

1. *Simplicity.*—It must be easily and cheaply worked, and require a minimum of skilled labor.
2. *Durability.*—It must do its work with but little repair or replacement.

As to the material to be used in the manufacture of the gas, the conditions are:

1. *Richness.*—It must contain the necessary carbon.
2. *Cheapness.*—It must be generally obtainable in large quantities at low prices.

These qualifications are met by the slack or fine bituminous coal, which are the least expensive of all coals, and are obtainable in nearly all markets at low rates.

These points established, it remains to decide upon the kind of gas to be made. This must be calculated to meet all the wants of those for whose uses it is intended. Here we find it necessary to consider the following:

1. *Quality.*—The gas must contain all the carbon possible, consistent with the other necessary conditions.
2. *Cost.*—It must be low in cost, especially in view of its use in large quantities.
3. *Cleanliness.*—It must be as free as practicable from impurities, and must be clean as regards the more perceptible.
4. *Transmission.*—It must be capable of easy carriage to reasonably long distances, and through small as well as large pipes.
5. *Temperature.*—It must have a constant high flame temperature, and must ignite under all conditions, when desired.

For general adaptability to the wants of all classes of consumers, the requirements named must be met, and the more completely met, the greater will be the success of the gas offered.

In many cases, a good producer gas accomplishes all that is needed, and, used in a well constructed regenerative furnace, is much cheaper than coal; but its usefulness is confined to places where such furnaces can be constructed, if high flame temperature is required, or where low heats are sufficient, and obtained without regeneration. Outside of such confines, it is not economical, and is seldom useful.

Without discoursing on the relative merits of other gases, I believe that the gas best suited for general fuel

* A paper read before the British Iron and Steel Institute, New York meeting, October, 1890.

purposes is water gas. Its flame temperature is high, it is cleanly, reasonably free from impurities, and it can be transmitted to long distances.

The one possible factor to which objection might be made is its cost. If it meets this requirement, there is no further bar to acknowledgment of its claims. Can it be made from the cheapest of materials offered in the general market for gas-making purposes? In discussing the lions in the path of success in this direction, the *London Journal of Gas Lighting*, some months ago, pronounced the following ultimatum:

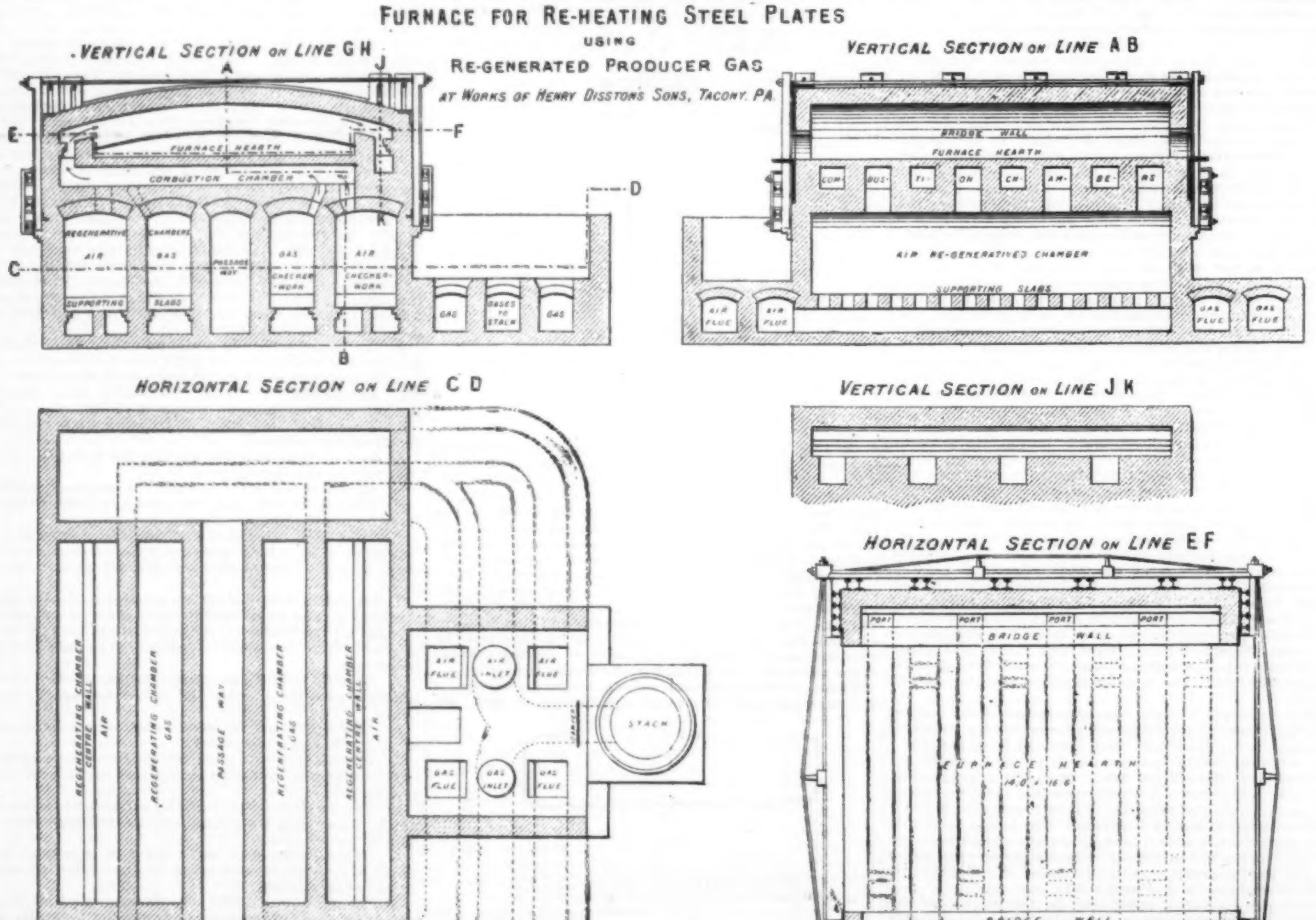
"The slack, however wet, dirty, dusty, sulphurous, or stony, should be tipped into the hoppers of the gas-making cupolas, and gasification should go on continuously and completely, so that nothing but gas and ashes should remain of the material put into the apparatus."

This can be done, and is done, in many places, with the Loomis apparatus, which is using the cheap coals mentioned, as well as the more expensive anthracite coals and coke. This apparatus is the only one that I know of in successful operation making water gas directly from the bituminous slack coals that are found in abundance in many parts of the world. It is a simple fuel-gas generating machine, and it will not only make as much water gas from a ton of this slack coal as can be produced by any other method from the same quantity of anthracite or coke, but it also utilizes the blast gases for making the steam necessary to run the engines and exhausters, and for decomposing, leaving a surplus for other work; or the blast producer gas or generator gas can be used in regenerative, reheating, annealing, melting furnaces, etc. For these purposes, the producer gas made by this apparatus answers all requirements, as can be shown by demonstration in the several places where it is so used.

Water gas generators, to be economical producers of gas, must be so constructed that they will continuously make a first-class quality of gas for the full period of a twenty-four hours' run. In all the generators using the up-blast system, after a few hours' run the quality of the gas has become much poorer than at the beginning, when the fires were fresh, on account of the clinkers and ashes that accumulate.

In the Loomis generator this is obviated, and the gas is of as good quality at the end of a twenty-four hours' run as at the beginning or any part of the run. This is due to the peculiar construction of the generator, and the action of the exhauster in collecting the ashes at the bottom of the fire and in the ash pit. In the process of exhausting before making a run of water gas, this is highly heated and useful for superheating the steam before it strikes the incandescent coal, and in this way the carbon is nearly all extracted from the coal, less clinker is made, the gas is freer from carbonic acid, and increased production is obtained.

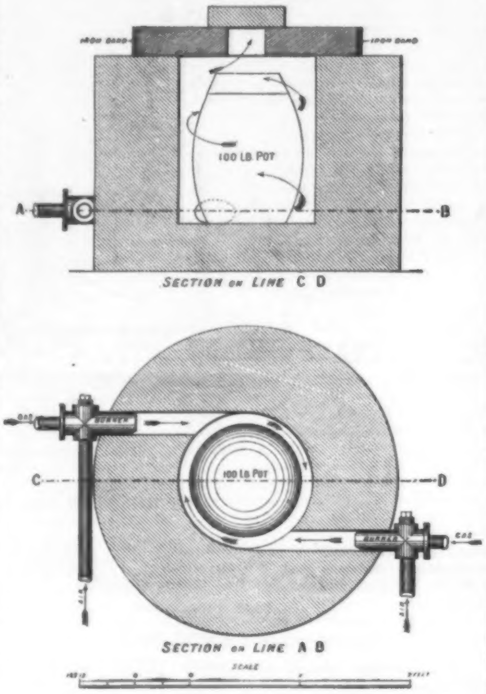
FURNACE FOR RE-HEATING STEEL PLATES USING RE-GENERATED PRODUCER GAS AT WORKS OF HENRY DISSTON'S SONS, TACONY, PA.



In the matter of quality, a high grade of product should be aimed at, and the water gas made as pure as possible, so that it can be used, where practicable, without purification. In works where it must be purified, the better the quality of the gas, the less the expense for purifying.

The claim has been made that the water gas that can be made from a given amount of coal must be less economical than the coal used directly, both on account of the smaller number of units of heat contained

SPIRAL FLAME POT FURNACE. FOR WATER GAS.



in the gas, and the labor and expense of making. Where coal can be well fired, and gases economically burned direct from the furnace, this is in many instances true, but the great fields for water gas lie in the special uses for the many kinds of metallurgical work and kindred work where coal directly used cannot enter as a comparative factor, and for domestic purposes, where the gas is proving itself as cheap as the coal, if not cheaper, while it accomplishes results that are not obtainable with the solid fuel.

In estimating the economy of its general uses, another factor must be considered. This is application. In this particular, the threshold of investigation has scarcely been crossed, yet much has been accomplished, while the future is fruitful of certain realization. Until lately, the gas has not been obtainable for the purposes of experimenting in large quantities, and as yet, in special work, the methods of application are comparatively crude. Within the past few years, however, much has been done in the face of untoward circumstances, and you can now be shown the gas in use in many ways where it has supplanted coal, and wherein it has been found more economical than to fire coal, without taking into consideration any other features of advantage.

In nearly all branches of metallurgical work wherein the gas can be applied, however, there is found:

1. An increased product.
2. A better grade of product.
3. Direct economy in cost.

Increase in amount of product arises from the saving in direct labor, as can be most easily seen, perhaps, in forge shops and the like, and from the gain in the personal condition of the workmen, owing to the increased healthfulness of their surroundings.

The gain in grade of product arises chiefly from the uniformity in the temperature and the quality of the fuel.

The economy in cost needs no explanation. I may state, however, that in some large works which have changed from coal to the use of fuel gas, the gain in direct economy has been proved to be from $33\frac{1}{3}$ to 50 per cent. in labor and over 40 per cent. in fuel.

In many instances, the gain from having a sharp, quickly heating flame is such as to overbalance the question of more direct saving in cost of production, and it is not infrequently demonstrated that, by this means, workshop material enough is saved to alone pay all the productive cost of the gas.

Another feature worthy of consideration is economy of space in locating furnaces or other appliances for the use of the gas, especially where it is desirable that these should be grouped together as closely as possible. It also renders possible the location of furnaces, heaters, forges, etc., just where desired, without necessity for considering the questions of convenience that frequently arise where there must be either coal carriage or storage.

With this, too, may be considered the fact that the heat from the gas is brought under closer control than that from the coal fires, and there is less heat generated into the room or space surrounding the point of application. This perhaps may seem of minor importance, but in these days of sanitary investigation and of shortening the days of labor, it will be found no little advantage to keep the temperature of the workroom as far as possible under control.

In many parts of the world inventors are devising new applications of this gas, and with marked success. It is so well made and so easily handled that its application in many new channels amounts to little more than ordinary manipulation and direction by those who understand the work to be done.

Among the several places in this country where the gas made by the process I have named has been ap

plied to such a variety of uses as plainly shows its adaptability as a general fuel, as regards both efficiency and cost, are the saw works of Henry Disston & Sons, which you will be invited to examine on your journey from New York to Philadelphia. There you will see the generators at work on steady and continued runs, and will see the two gases, *i. e.*, the water gas and the producer gas that is made intermittently with the water gas, both carried to holders; and delivered under pressure at different parts of the works.

This is the first place of which I have knowledge where producer gas has been stored in a holder, and thence delivered cold to different furnaces at distances from the generators, being fired cold at such distant points. The process of manufacture and the manifold utilizations of the different gases, but especially of the water gas, will be of interest. Full facilities for a

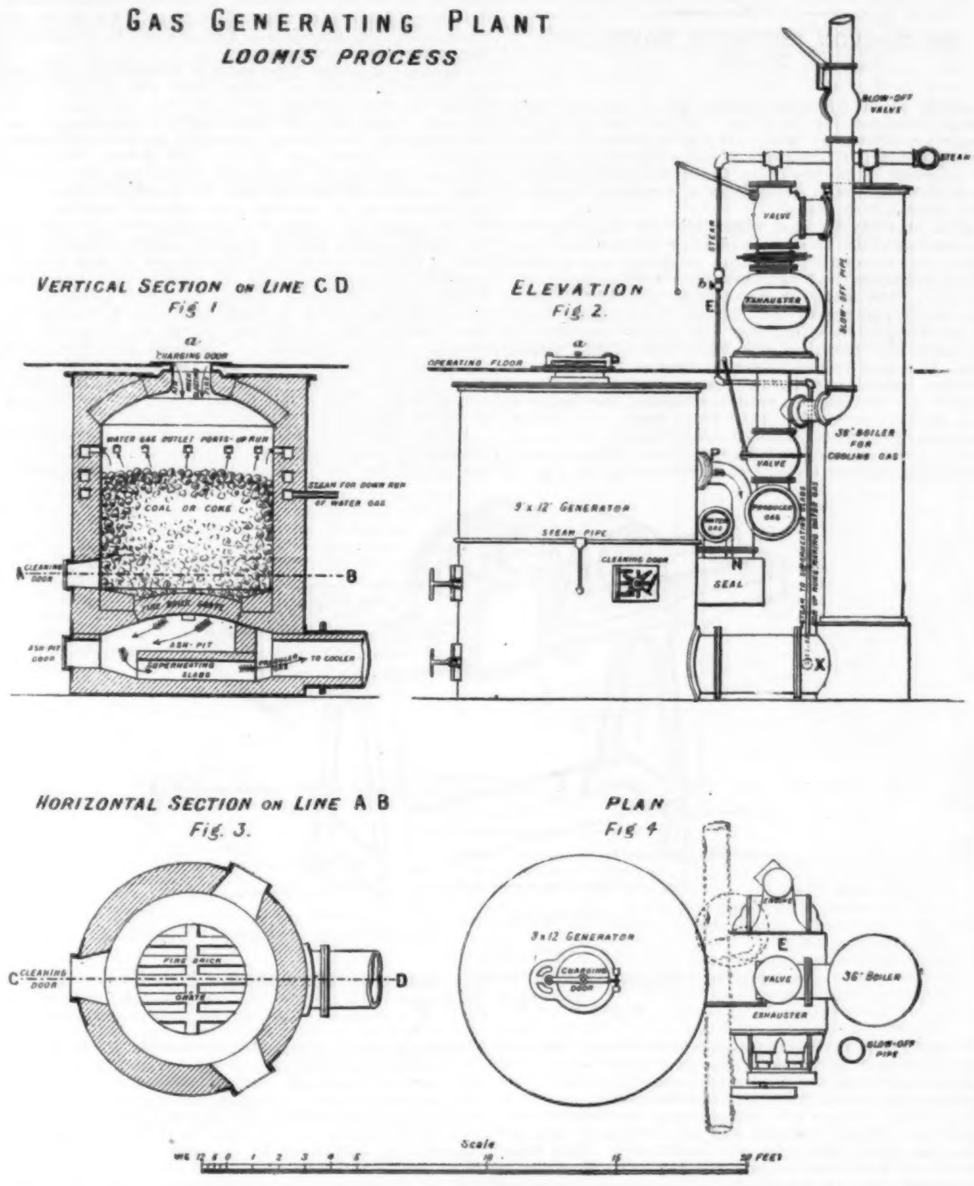
When the coal is in a proper state for decomposition of steam the exhauster is stopped, and the door, A, shut, and steam is let on at the valve, B, at point, X, and it passes through the ash pit and grates, where it is highly superheated, then through the mass of coal, making water gas, which passes out at P, through the seal box, N, to the water gas holder.

After a run of about five minutes the steam is shut off, the door opened, the exhauster started, and the process of making producer gas is again commenced.

Since the foregoing paper was written, the following actual results have been obtained melting brass in crucibles with water gas with improved furnace:

In melting 2,000 lb. of brass in 100 lb. crucibles, 12,000 cubic feet of water gas was consumed.

In using same size of crucibles in works that are



thorough examination of the process of manufacture will be given, as well as full liberty to make any tests or experiments desired.

Estimated cost of 1,000,000 feet of water gas based on actual results, coal at $3.00 per ton.

Coal 25 tons, $3.00 per ton	$75.00
Coal for steam, 3 tons, $3 00 per ton	9.00
Labor	22.00
Extra for supplies and repairs	4.00
Purifying	5.00
	115.00
Received for producer gas	40.00
	75.00
Interest on plant and depreciation	25.00
	100.00

Cost per 1,000 feet, $0.10

In the practical using of water gas, 20,000 feet often accomplishes better results than a ton of coal directly fired. In some cases more is used.

This has been accomplished by new and improved methods of application, and will be improved upon as necessity demands and appliances are perfected.

I may say, in conclusion, that in no place this gas has been put into use has any thought been given to a return to coal. The solid fuel, once supplanted, will never be sought for again.

Description of the Loomis Generator.

Figures 1 to 4 show the way in which producer gas and water gas are made alternately.

In bringing the coal to an incandescent state for making water gas, the door, A, is open, and the exhauster, E, is started and draws the air down through the coal and ash pit and up through the cooling boiler, and the producer gas made by this operation is forced through the pipe, C, to the holder.

melting from five to ten tons per day with coal, it takes 2,000 lb. of coal for 2,000 lb. of brass.

Units of heat in 12,000 feet water gas used, 3,600,000.
Units of heat in 2,000 lb. coal used, 27,000,000.

Or seven and one-half times the amount that is in the gas used.

One ton of coal will make 40,000 cubic feet of water gas, which will accomplish as much as 3½ tons of coal in this work.

The cost of labor in making water gas will be less than in firing coal direct. The producer gas made, in addition to 40,000 feet of water gas, from a ton of coal will yield all the steam needed and pay interest and repairs on the plant.

The coal used for making the gas, being bituminous slack, only costs two-thirds as much per ton as that used with direct firing.

One ton of coal to make the gas, costing $3.00.
3½ tons at $4.50 per ton will cost $13.50.
Saving on coal in melting 3½ tons, $10.50.

As it only requires two-thirds the time to melt with gas that it does with coal, here is a great saving, and less space is needed for furnaces, as only one-third the number is needed. Metal is not wasted in the ash, and crucibles will last much longer.

[Continued from SUPPLEMENT, No. 773, page 12346.]

STEREOTYPING.*

By THOMAS BOLAS, F.C.S., F.I.C.

II.

ALL is now ready for laying the mould in the casting box, the casting box having been warmed by a gas jet underneath, or I might have warmed it by casting a few blanks in it. The mould is laid face upward on the horizontal slab of the casting-box (Fig. 4), the brown paper flap hanging a little over the lip of the box. The pica-high gauges are laid along the gutters formed by the clumps, the top leaf of the box is closed down and clamped by the screw, and the casting box is swung on its axis, so as to bring the lips to the top.

When stock sizes have to be stereotyped it is convenient to use set gauges, like Figs. 6 or 7, but in other cases it is usual to employ adjustable gauges, such as Fig. 5.

When the mould is charged with type metal, it is necessary, in order to obtain a good cast, that the whole of the metal inside should remain fluid until the mould is completely filled with metal, as if any part solidifies before the mould is full, the cast is sure to show curved streaks where the cast has solidified, and the fresh metal has not run up so closely as to make a sound cast. This is most noticeable at the back of the cast, where the casting box exercises the most sudden cooling action on the metal, and the object of heating the

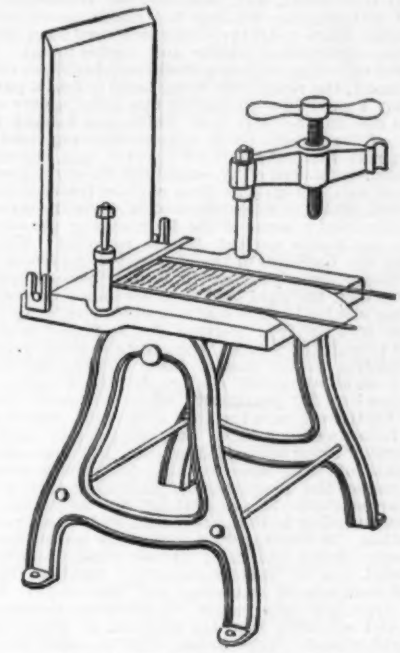


FIG. 4.—THE CASTING BOX.

casting box is to diminish the tendency to this sort of thing. Heating the casting box is generally insufficient in itself, when the cast is large, unless the heat is raised to nearly the melting point of the metal—an obviously inconvenient course. It is very much more convenient and satisfactory to warm the box only slightly (say to about 100° centigrade), and to cover the face with a non-conducting coating, a coating which may be extremely thin; in fact, it is sufficient to sponge the iron plate over with a very thin wash of jewelers' rouge (finely divided ferric oxide, or, practically, much the same thing as finely divided iron rust) and water, a film of the oxide so thin as to be scarcely noticeable serving to retard the solidification of the metal during the short time required to fill the mould. Although a thin wash of jewelers' rouge is the best coating material to employ when very delicate castings of type metal are to be made in metal moulds (as, for example, in casting the thinnest "leads"), a thicker and coarser mixture, made by stirring ¼ lb. of red ocher into half a pint of water, is often used; this being applied with a brush. London stereotypers, however, more usually lay a sheet of thin cardboard over the back plate, or a sheet of thin paper will serve, the thin paper being quite as effectual as the card in preventing the chilling of the metal, but stereotypers generally prefer the card, as lasting longer and being easier to handle. The card, however, is liable to blister, and so cause inequalities in the thickness of the plates. In this connection I may mention that, in the absence of a metal casting box, excellent work may be done by using two slabs of dry wood, held together by screw clamps.

All is now ready for the casting of the stereotype. In this pot is some metal ready melted, and soon I shall have something to say as to the composition of the metal. To ascertain whether the temperature of the metal is about right, a strip of card or of old mould is immersed in it for a few seconds. If the card becomes

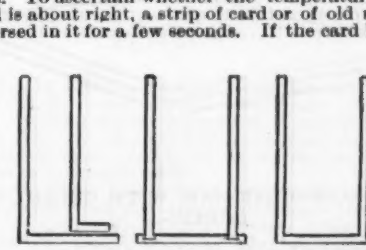


FIG. 5. FIG. 6. FIG. 7.

STEREOTYPE GAUGES.

of a medium brown the heat is right (about 320° to 330° centigrade), while if it chars and blackens the temperature is too high. Should it, on the other hand, merely become yellowish or light brown, more heat must be applied; when the metal is too hot, it can be rapidly brought down by stirring in some cold metal. It is important that, when poured, the surface of the metal should be clean and free from scum or oxide, as this might lodge in the cavities of the mould and render the cast unsound; and the most convenient way of cleaning the surface is to throw into the pot some powdered resin, which melts and so far agglomerates the oxide that it can readily be removed by skimming with a perforated iron spoon. Sufficient metal is now taken out of the pot by an iron ladle—one with a flat pouring

* Lectures delivered before the Society of Arts, London, 1890. From the *Journal* of the Society.

side (Fig. 8) is often used—and the metal is poured steadily, but not so quickly as to cause splashing, into the mould. Under ordinary circumstances it makes but little difference whether the stream is poured against the back plate of the casting box or against the face of the mould, although the former is the most usual course, and some persons make a point of draw-

Fig. 8.—FLAT-SIDED LADLE.

ing the ladle along the lips of the mould during the operation of casting.

The metal used for stereotyping is much the same as ordinary type metal, only, as a rule, the stereotyper is content with an alloy tending too much toward softness, while of late years type founders have been moving in the direction of harder and harder metal. An alloy well suited for ordinary work contains 20 per cent. of antimony, the remainder being lead; or lead 4 parts, antimony 1 part. For preparing this alloy, a very safe lead to use is the soft lead which has formed the linings of tea chests, or if commercial pig lead is used, a soft sample should be selected, and this may be sufficiently judged of by scratching the surface with the finger nail. Hard pigs often contain traces of zinc; this metal, which is especially bad in stereotyping alloys, being used in some of the desilverizing processes, and the last traces are not always removed. When, however, the hardness of the pig lead is known to be due to antimony, copper, or tin, it may be used quite safely; in fact, the hard lead then becomes more desirable than soft lead. The lead and antimony being put together into the iron melting pot, sufficient heat is applied to melt the former, when the antimony gradually dissolves in the melted lead, forming an alloy which fuses at about 300° centigrade. Lead melts at something like 330° centigrade, while antimony fuses at 450° centigrade, or a low red heat; the stereotype metal following the general rule that alloys melt at considerably lower temperatures than the mean melting points of their constituents. Sometimes stereotypers reduce the proportion of antimony so that the alloy only contains 10 per cent. of the metal, but in this case the alloy is noticeably soft, and wears badly in printing. A very superior stereotype metal, which is not only harder but more fusible than the above mentioned, can be made by melting together three parts of lead, one of antimony, and one of tin. Old mixed type generally makes an excellent stereotype metal, and will often bear the addition of nearly half its weight of lead. Type metals, like so many alloys, are harder when the cooling has been very rapid than when it has been comparatively slow, and casts obtained in a given alloy, by the paper process, are consequently softer than those by the striking process of Carez and Didot.

The most positively objectionable impurity likely to find its way into the stereotyping metal is zinc, this metal making the alloy flow badly, and the face of the cast rough and patchy, doubtless by its tendency to separate from the other metals. It is, therefore, important to keep watch against its introduction into the stereotype foundry, and in melting up old type or scraps, any portions which remain unmelted, and float on the surface after the bulk is fused, should be skimmed off, as these are likely to contain the lighter and less fusible zinc. The larger the proportion of lead in the stereotype metal, so much greater is the evil effect of zinc. Zinc in lead or in type metal may be removed by calcining at a low red heat, the zinc oxidizing with the first portions of the lead; but the same treatment also removes the antimony, or at any rate a considerable proportion of it. The tendency of antimony to oxidize is so much greater than that of lead that stereotype metal used many times becomes softer from the loss of antimony. A little arsenic—say 1 or 2 per cent.—increases the fluidity and hardness of a stereotyping metal.

We now take the cast out of the box, and the usual thing is to trim it, or cut it up into pages with a circular saw, and as the cuttings are carried round by the saw, and thrown upward and forward by the ascending side, it is usual to fix a screen (as shown in Fig. 9), to

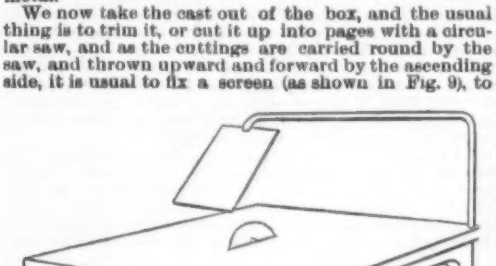


Fig. 9.—CIRCULAR SAW WITH CELLULOID SCREEN.

prevent them going into the eyes of the operator. The screen is ordinarily made of sheet metal, but you see in the case of the saw bench sent here by Messrs. Harrild & Sons a neatly fitted and curved glass plate is used. Generally speaking, however, I have preferred to use a leaf of the transparent flexible celluloid, which can now be readily obtained as thin as a card, and as transparent as glass.

Instead of a circular saw, the tool known as a zinc hook (Fig. 10) may be used for dividing the plate. A

Fig. 10.—THE ZINC HOOK.

metal straight edge is used as a guide, and the cutting edge of the zinc hook is drawn along it a sufficient number of times to plow a groove half through the plate, when it becomes easy to break it.

For trimming the edges a hand plane is ordinarily used in conjunction with a shooting board, the ordinary wooden shooting board and jack plane of the joiner answering the purpose very well. The cut (Fig. 11) represents an iron shooting board and iron plane

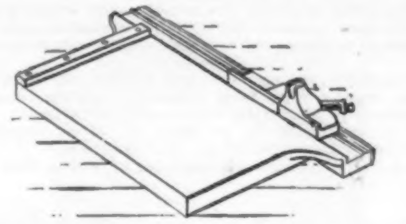


Fig. 11.—IRON SHOOTING BOARD AND PLANE.

specially made for stereotypers' use, a second plane being provided for beveling. When the trimming planes are driven by power, the arrangement is generally substantially similar, the plane moving to and fro on a guide, while the plate to be trimmed is fed up against it, although sometimes a revolving cutter is used instead of a plane.

Thin stereotypes, cast pica high for mounting on blocks, ought not to require planing at the back, provided that reasonable attention is devoted to matters which influence their thickness and truth, such as the flatness of the slabs of the casting box, the accuracy and right placing of the gauges, the keeping of the mould flat while drying, and the proper condition of the cardboard covering the back slab of the casting box. It is easy to cast plates so true as to require no planing, indeed, so true that the arrangement ordinarily used for planing, or, rather, scraping, the backs of thin stereotypes would make them worse, not better. The arrangement is a kind of drawbench in which the plate is slowly forced under a stout knife placed almost vertically, and one form of it is represented by Fig. 12.

than when made up in the chase. As a matter of fact, stereotypers very seldom send out the blocks too high, as the printer finds it much easier to pack up than to plane off.

Printing from stereotypes becomes much more easy

Fig. 13.—GAUGE FOR HEIGHT.

and certain if, instead of being mounted upon a material which, like wood, varies in thickness with difference in the degree of dryness, the stereotypes are either cast type high in the first instance, or are mounted upon some firm foundation not subject to considerable variations in thickness.

Casting the plates type high is a common practice for ephemeral work, as in that case the plates can be melted as soon as done with, but it is the usual practice not to cast the plate quite solid, a number of hollow spaces at the bottom, generally arched or domed, serving to lighten the plate. Any person with elementary notions of handicraft can devise for himself ready means of making cores for placing in the casting box so as to produce the required cavities, and several ingenious forms of adjustable cores are now on the table, among which may be specially mentioned that of Harrild & Son, in which a set of core bars of graduated sizes enables one to readily cast type high blocks to any required width. For very small blocks it is more convenient to cast solid, and if reasonable care is taken, the blocks may be cast so accurately to type height that planing at the back becomes quite unnecessary, and the sides may readily be squared up with the hand plane, Fig. 11, or sometimes it is more convenient to cast small metal mounting blocks, and to solder the thin stereotypes upon these.

Metal mounting blocks, upon which bevel-edged stereotype plates are held by catches placed round the edges, are on the market in various forms, much

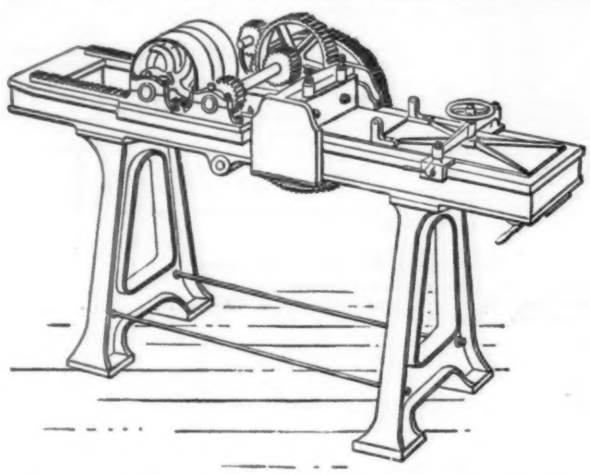


Fig 12.—DRAW BENCH FOR SCRAPING THE BACK OF THE PLATE.

On referring to the diagram it will be seen that the traveling part is one with the two racks, while the double gearing and the arrangement for reversing by shifting the strap from the middle pulley—which is idle—to the right or left, according as one wants backward or forward motion, will be obvious to any one who has given attention to machinery. The slow, heavy cut, with a cutter at right angles to the plate, is essentially wrong, and tends to drag the plate out of shape, and, unless care is taken, will sometimes lift it from the bed of the machine. A machine tool for cutting stereotype metal will not work efficiently at a much less speed than twelve feet per second between it and the metal. In ordinary cases the cut is clean and easy with such a speed and an angle of 60 deg. on the approaching side, and 15 deg. is a good angle for the cutting edge, leaving an angle of relief of 15 deg. When a cutting tool rapidly removes small shavings of stereotype metal—as in the case of a circular saw or rotary cutter—there is a tendency for the clean particles of metal to weld together, and also for some of them to weld upon the clean surface of the work, thus making it rough, but a minute film of thin mineral lubricating oil prevents the tendency to welding, and it is generally sufficient to allow a brush charged with the oil to very lightly play against the cutter or the work according to circumstances. The free use of oil on stereotypes is objectionable for obvious reasons. For heavy work water containing a little soap is more efficient, but it must be used freely. The above remarks as to the relation of stereotype metal to cutting tools apply more especially to the ordinary and rather soft alloy. It is a matter of surprise to me that a planing machine with a revolving cutter, like that used for thicknessing floor boards, is not always used for the backs of stereotypes when planing is required.

In most cases—at any rate for jobbing work—the stereotype plates are brought up to type height by being nailed or screwed down on mahogany boards, these being, roughly speaking, three-quarters of an inch high; and, from the printer's point of view, it is very desirable that the thickness of the whole should exactly equal the height of the type, a matter which may very well be ganged by a sort of bridge (Fig. 13), under which the mounted stereotype can be just passed if it is the right height. Wood blocks expand when exposed to damp, and contract when they dry, and consequently they vary from time to time; so printers, when using wood-mounted stereotypes, would save time by passing them one at a time, and face downward, under such a bridge set to type height. The low places can then be readily brought up with paper patches in far less time

cleverness being sometimes noticeable in the devices for enabling the printer to build up any required size of mounting block out of stock sizes, and several such arrangements are on the table before you. In the case of an ingenious device by Mr. Harvey Dalziel, the loose clips are avoided, and by dividing the mounting block diagonally, variations in size are very readily provided for by the insertion of suitable distance pieces. Fig. 14 illustrates the arrangement. The small dia-

Fig. 14.—DALZIEL'S STEREO-BLOCKS.

gram at the west side is a sectional view showing the clips, which are one with the blocks, and it also shows the coring of the blocks, while the diagram under it shows a pair of twin blocks in plan. Next we have the same adapted for a larger plate by the insertion of one of the various distance pieces, a series of which is shown on the outer side of the group. Fine adjustments can be made by inserting an ordinary lead, and it is obvious that these adjustments can be made to take effect either across or along the page, or may be apportioned between the two.

A very firm and satisfactory blocking up of the stereo plate is a method due to Brightley. A few short pieces of wire are soldered to the back of the plate, and it is now laid on its face and surrounded with a type high border. A mixture of calcareous cement and water is now filled in level with the top of the border, and a flat plate slightly oiled is laid over and weighted. Brightley used Roman cement, but in the present day Portland cement is more convenient. This method is unsuitable when the plates are wanted for immediate use, as in ordinary cases the mould should not be removed for about twelve hours, and two days should elapse before the mounted stereotypes are used for printing.

It very often happens that the stereotype requires some work done upon its face, such as cutting away the parts corresponding to large white surfaces, raising low parts, or "sinks," or soldering in letters or electrotypes. For chipping away extended whites, a very

convenient tool is the ordinary carpenter's gouge, driven by a rather light mallet, an assortment of four or five gouges, the narrowest about three-sixteenths of an inch across, being ample. When chipping away the metal with gouge and mallet, it is desirable to place the stereotype on a planed iron surface, provided with a transverse bar against which it can rest, the iron shooting board (Fig. 11) being convenient for this purpose. For working in narrow places, and close up to the type face, a "firmer" chisel of suitable width may be used, or a scraper shaped like Fig. 15, and one angle

FIG. 15.—TRIANGULAR SCRAPER.

of the scraper may advantageously be ground on the edge of the grindstone, so as to shape it into a chisel-like tongue about a sixteenth of an inch wide, or a special tool, like Fig. 16, may be used for scraping be-

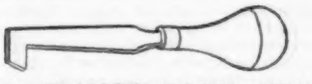


FIG. 16.—PARALLEL-ENDED SCRAPER.

tween the lines. Sometimes a routing-out machine is used, in which a conical, dome-shaped revolving cutter, provided with universal movements, is brought down on the plate, but in ordinary cases there is little or no saving of time by the use of such a machine. When there is a "sink" on the face of the stereotype—this being generally the result of an arching of the mould*—it may be brought up by laying the plate face down on a planed iron surface (a sheet of paper being interposed if this is thought necessary) and hammering on the back with a broad and round faced hammer, such as that used by shoemakers for beating out leather; a little paper packing being then pasted on the back to support the hollow. In beating down the "sink," care must be taken to strike in the middle of the place rather than at the edges, and to strike the fewest blows that will do the work, otherwise the plate may be distorted so much as to render it useless. In the case of the thick curved stereotypes used for newspaper work on rotary machines, the machine minder will often bring up a low line† by driving a chisel obliquely into the metal above it and below it.

Cutting out a false letter and soldering in a type requires some care and watchfulness, but it is very easily done. The stereotype is clamped face upward on the punching-out slab (Fig. 17), and with the line contain-

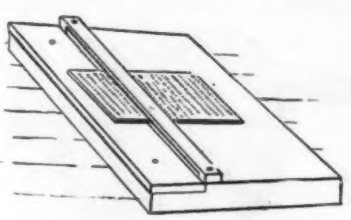


FIG. 17.—PUNCHING-OUT SLAB.

ing the false letter immediately in front of the bridge. The adjustable part of the bed, shown at the left of the diagram, being now set so as to leave a gap exactly under the line, the chisel (Fig. 18) is used to make an indentation round the letter, at any rate on those sides where access can be had, the chisel being placed with the unbeveled side next the letter to be removed, and being held vertically. A punch like one of those shown in Fig. 18, and of the right size for the

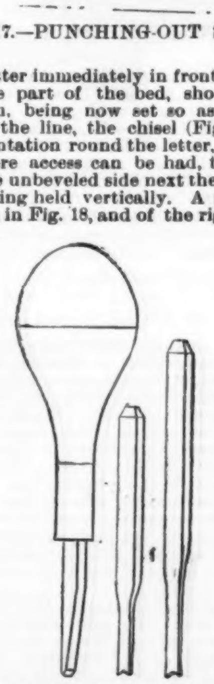


FIG. 18.—TOOLS FOR REMOVING FALSE LETTERS.

letter to be removed, is now held firmly atop of the letter, and is driven through the plate by a hammer. Any metal driven beyond the plane of the back may now be cut off with a sharp chisel, and if any indentation of the face round about the hole is visible, it can be dealt with as recommended in the case of a "sink." The hole is now trimmed, by means of a rectangular file,‡ to the bare size of the type to be inserted, and the type, after having been scraped clean on the sides, is inserted from the back. The face of the letter having been adjusted to its exact position and level, the stereotype is laid face downward on the punching-out slab, no paper being interposed between them, a little powdered resin is dusted on, and with a rather fine-pointed soldering bit a trace of solder is applied at two opposite points of the joint. The shank of the type is then nipped or broken off and the place is filed or scraped level. Sometimes a skilled workman will put a patch of solder over a false letter, and out of this engrave the required character, but such a method of working is more usually adopted when a dot or the tail of a letter is broken off and must be replaced.

The soldering is very easy if a few points are attended to. The copper bit being heated to a heat a little under redness, is rapidly cleaned about the point with a file, and quickly dipped into an acid solution of chloride of zinc,* and then rubbed on a stick of soft solder, which itself has been moistened with the same solution. It thus becomes well amalgamated with the solder or is "tinned," to use the expression of the workshop. To keep the soldering bit in a good condition, its tip may be rapidly dipped in the acid chloride of zinc solution after each heating, and being then charged with solder it is ready for use on the stereotype plate, and if the part to be soldered is sprinkled over with powdered resin, this will be sufficient protection, and the small drop of solder carried up on the tip of the bit will unite and flow readily. The acid chloride of zinc solution should not be applied to the type metal, as it rather corrodes it than protects it.

When much soldering has to be done, as for example if electrotypes of wood cuts are to be soldered into stereotype plates, a soldering bit, heated by a small gas blowpipe, is a great convenience and saving of time, and the device represented in Fig. 19 is a specially con-

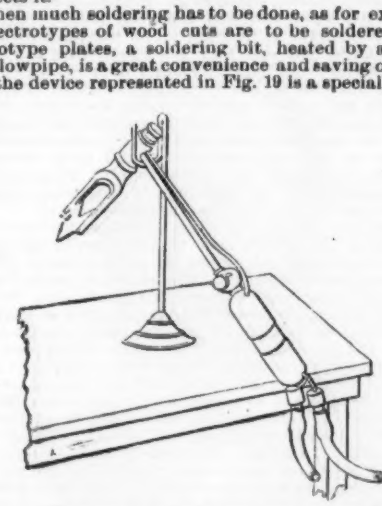


FIG. 19.—SOLDERING BIT HEATED BY GAS BLOWPIPE.

venient one for the stereotyper, this sketch, like some others I have put before you, being taken from Monet's very useful work, *Procedes de Reproductions Graphiques*,† and the instrument itself can easily be constructed by any all-round mechanic. The tubes leading gas and air respectively (the air being conveniently supplied by a foot bellows) are shown first passing through a wooden handle and thence into the cylindrical head of the apparatus, where is fitted a small Herapath's blowpipe, the flame of which plays upon the small copper bit held, as shown, by two lugs extending from the cylindrical head. A cock is placed on the gas pipe just over the handle, and where it can be operated by the thumb of the right hand, while the crutch shown on the figure forms a convenient support for the blowpipe when not in use.

Although very little care and attention on the part of the workman will enable him to use ordinary soft solder of the tinman without fear of melting the adjacent parts of the plate, there are cases where it may be desirable to use a more fusible solder, in which case Wood's cadmium solder may be employed. It melts at a temperature considerably under that of ordinary solder, works nearly as easily, and is quite as strong. It is prepared by melting together cadmium 2 parts, tin 4 parts, lead 2 parts.

An alloy of bismuth 2 parts, tin 1 part, and lead 1 part, forms a solder easy to use, moderately strong, and melting below the boiling point of water.‡ When figures have to be altered several times, this solder is convenient to use, as those first soldered in can be readily removed by immersing the plate in boiling water or heating it till, when touched with a wet finger, one can just feel steam form, then giving the figure a slight tap to drive it out.

In stereotyping for newspaper work everything is carefully studied to attain speed, especially in the case of evening papers, and it becomes possible to mould a page and cast a plate in about ten minutes. In such cases the plates are cast curved, so as to fit the cylinder of the machine used.

Two workmen beat the flong to make the mould; a rolling press being often used to finish the moulding. There is generally very little packing of the whites to be done, so it suffices to sprinkle a little whiting upon the back of the mould, and scrape it into the hollows with a straight edge, after which the final thickness of brown paper is pasted on, and the forme is run under a hot press to dry, the heat being as great as can be ventured upon without damage to the type. In two or three minutes the mould is removed, finally dried on a hot surface for another similar period, is dusted with French chalk, and is then placed in a curved casting box (Fig. 20), the metal being poured in at the side of the page, while in the older pattern of curved casting box it was poured in at the top. The metal is poured from a large three-handled ladle like that used in iron foundries. The trimming of the cast is generally done while it is warm, and by slow-moving tools, as chips

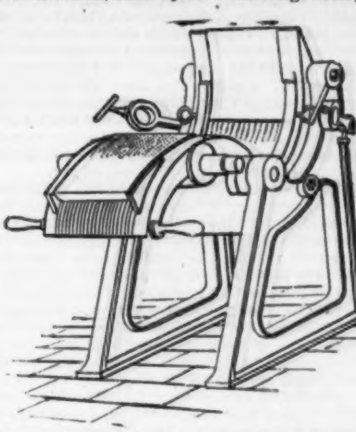


FIG. 20.—CASTING BOX FOR CURVED PLATES.

rapidly removed from the hot metal are more likely to weld on the freshly cut surface than is the case with cold metal. Therefore, the ordinary machine for boring the inside of the cast, and in which a single knife is made to revolve slowly and take one heavy cut (Fig. 21), is less unsuitable than might at first sight be supposed. But in this case, if a revolving cutter were used,

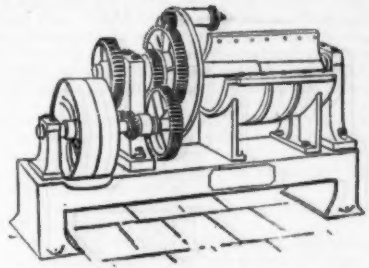


FIG. 21.—MACHINE FOR BORING THE INSIDE OF THE CURVED PLATE.

and were fed with slightly soapy water by a series of conduits in the cutter bar, it is quite likely some economy of time would be effected. Soap, like oil, soils the surface of the type metal sufficiently to prevent welding.

A common form of apparatus for trimming and beveling the edges of the curved stereotypes is that shown in Fig. 22, the plate being clamped down on a

FIG. 22.—TRIMMING MACHINE FOR CURVED PLATES.

suitable saddle, and trimmed by adjustable knives, the holders of which are moved backward and forward by hand. Another trimming machine is represented by Fig. 23. In this case we have a revolving cutter, and the plate is fixed upon a saddle which traverses and rotates by hand gearing.

Occasionally plates intended for printing on rotary machines are cast flat, and afterward bent to the required curve, and there are two methods of doing this. In one case the plate, previously warmed, is forced down into a curved die by a sort of platen formed of stiff leaves of spring steel, but when the same machine is intended to bend to any curve, a bed piece, similarly formed of plates of spring steel, must be laid over the die. In the other case the stereotype is laid between steel plates thin enough to spring, and is rolled several times through a set of three rollers, one of which is adjustable so as to give the required set.

In either case it is necessary to place paper or a blanket between the face of the stereotype and the steel plate, and the results of the bending are seldom quite satisfactory, unless the plate to be bent is fairly solid, as in the case of an ordinary newspaper page, any extended whites interfering with the regularity of the bending. In the case of electrotypes, which are ordinarily backed up with a softer metal, the bending is easier, and electrotypes are often bent that they may be soldered into curved plates for illustrated newspaper work.

The work of the newspaper stereotyper is very seriously interfered with if any wood-mounted blocks are

* May arise from a scrap of metal or other foreign body under the flong, penetration of liquid metal through a hole in the flong, or the joint of the paper flap, from distortions of the mould during drying, or by careless clamping up in the casting box.

† The standing lines in newspapers and periodicals are often low to paper.

‡ Files of rectangular section down to a square file about 1-50th of an inch across can be obtained at the watchmakers' material shops of Clerkenwell or Soho.

* Commercial hydrochloric acid saturated with zinc, and when poured off from the excess of metal, is mixed with one-fourth of its bulk of hydrochloric acid.

† Procedes de Reproductions Graphiques, appliquees a l'imprimerie, par A. L. Monet. Super-royal octavo, 444 pages, 108 cuts in text, and 13 plates. Price 10 francs. Paris, 1888: Administration du "Bulletin de l'Imprimerie," 7 Rue Suger.

‡ Wood's fusible metal, referred to farther on, forms a still more fusible solder.

inserted in the forme he has to mould, the heat passing so much more slowly through wood than through metal as to make it almost a matter of certainty that the mould will be less dry when over such blocks; this being not only calculated to give a rough face to the lines, but also to lead to a distortion of the face of the mould in the second drying. This evil is especially apparent in the case of the zinc process blocks, which are made very thin, and are consequently mounted on an extra thick block of wood. The separate moulding of the blocks and casting type high, or the mounting of them upon solid metal bases, is so easy that there is scarcely an excuse for being so unfair to the workman as to send pages containing wood-mounted blocks when a stereotype is required in a minimum of time.

Probably the interfering influence of the wood mount is largely responsible for the tradition that the paper process is unsuited for the reproduction of the finest engraved work, but personally I am quite convinced that if all or most reasonable precautions * are taken to insure the very best results, stereotypes can be made by the paper process which are equal in fineness of surface and definition to the best electrotypes, and are superior in durability to many of the very thin shells of copper on a base of very soft metal which pass nowadays. In illustration of this I have on the table reproductions of fine engraved work, some of which I have done myself and others have been done for me by London stereotypers, a request for additional care having in almost every case had the desired result. Just before the lecture Mr. Dallas brought me this very finely stippled photo relief book, which you will admit is a crucial test object, and with it he brought me this paper process stereotype made from it by Messrs. Sharrow & Anderson, and if you look at these carefully they will bear out what I have said. The paper process is, however, very ill adapted for moulding direct from wood cuts, owing to the action of the heat and moisture on the wood, and is seldom employed for this purpose unless in the case of very small blocks, or when time necessitates it. The stereotype by the paper process is, when at its best, smooth, brilliant, and lustrous on the face, where the metal takes the impress of the compressed and hardened matrix, while the low parts, which are cast in contact with the spongy part of the mould, are always rough and often unsound in the

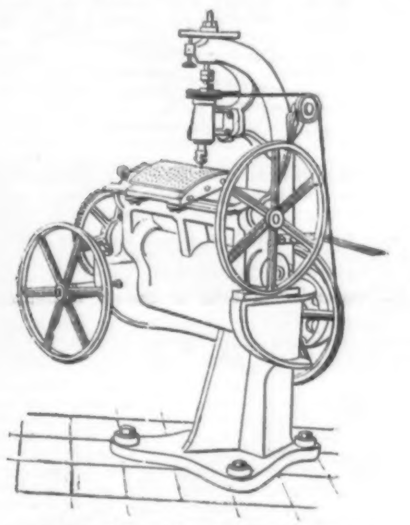


Fig. 28.—TRIMMING MACHINE WITH REVOLVING CUTTER.

sense of being permeated by holes and faults. The depths are nicely rounded and the square shoulders of the type shanks show not at all, or only faintly.

I have spoken of the circumstance that in all ordinary stereotyping work some moisture remains in the mould, and I want to show you that it is possible to make a fairly sharp cast in a mould which is quite wet. This forme is warm and I beat a piece of flong on it to make a mould, and I put the mould in the warm casting box. You see all is now quite wet, and signs of vapor are visible at the mouth of the box. On pouring in Wood's fusible metal, † which melts considerably under the boiling point of water—say between 60° and 70° centigrade—a very fairly good cast is obtained, the heat not having been sufficient to convert the water into steam. This experiment is interesting, not only as showing a possible means of making a stereotype in a shorter period than the usual time—although the high price of bismuth tends to put it outside practical work—but also as illustrating a point of some importance, that, in the case of a mould not very thoroughly dried, the best result is obtained with the metal at as low a temperature as practicable, whereas in the case of a mould baked for a long time, the hotter the metal is the better the result, provided it just stops short of burning the paper; so it is possible to have failures either from the metal being too hot or too cold. The use of French chalk on the face of the mould tends to minimize the mischief resulting from traces of moisture in the mould, but as it invariably makes the face of the cast a little rough, it should only be used when needed. Another use of French chalk is when numerous casts are required from the same mould, as it tends to prevent adhesion between the cast and mould. When a large number of casts are required from one mould, other precautions to be observed are to use a well cemented and ripened flong which is not too soft, to avoid making the mould too deep, and to beat with numerous gentle blows, rather than with a smaller number of heavy blows, as this tends to give a mould in which the depths are nicely rounded off, and do not follow the nearly vertical sides of the type face. Again, patches of old mould or pieces of thin sheet metal may be laid in the more considerable depths of the forme, so as to support the flong where subject to the greatest strain. Some stereotypers do this in the case of most ordinary work; while those who have a difficulty in beating the flong without shifting it do the same in the case of all very open formes.

The question of damage to type during the process of stereotyping is one of some importance, and it mainly steps in when a high temperature is employed for drying. If the forme is very tightly locked up in the chase it may, in expanding and softening under the heat, become elongated, while on the other hand it may become shortened by the pressure of the drying press. These two circumstances tend to make a newspaper fount become of unequal height, and the fount is rendered useless. In reference to this subject, Messrs. Caslon & Co. have sent me one of their circulars, dated April, 1880, from which I may quote the following:

"A remarkable instance of the dire results of severe locking has lately come under our notice. A daily newspaper was supplied with founts, in the manufacture of which special pains had been taken to produce an amalgam of the toughest and hardest consistency—and with remarkable success. Within a few weeks our attention was called to certain appearances in the types which led to a close inspection and consultation. The matter was approached by founder, compositor, stereotyper, and engineer, with a sincere desire to ascertain the cause of the serious phenomena, and the evidence led conclusively to but one result, viz., unnecessary pressure in locking. The tremendous force exerted on the columns had been such that the back of some of the types bore, in clearly defined ridges, the marks of the nick on the type against which it stood. In fact the metal was crushed into the space formed by the nick, and the feet of other types bore like impressions of the bevel of a lead or rule they stood next to. The body of the type was also found to be smaller, when tested by gauge, and worse than all, they had become longer, or, to use a founder's expression, higher to paper, by as much as a twelve-to-pica lead!

"There is no remedy for this evil after the mischief is once done; but there is a valuable practical lesson to be learned which all overseers of newspaper offices will do well to enforce. Let the formes be locked with only a moderate force, sufficient to secure safe lifting. With the enormous power at the operator's command, only a slight turn of the wrench produces enough pressure on the type to secure this end—which may be verified by experiment—and then we strongly advocate loosening the formes as soon as they are placed on the hot stereotyping bed so as to allow for expansion. When possible, lifting the formes at all should be dispensed with: they should be imposed and then slid along on a continuous bed or imposing surface right on to the moulding bed, so as to avoid all possibility of accident. With such convenience at command there would be no necessity at all for excessively powerful locking apparatus, and the ordinary wooden quoin and side stick would be found sufficient. . . . . We strongly advocate the insertion of wood furniture—say about two line pica reglet—between the long sidestick and the type; for in case of undue expansion of the type in the process of moulding for stereotyping, the wood would give way before the metal type, and the latter would therefore be preserved."

Since the date of the circular quoted, the typefounders have done much in the way of using harder metal for their types, but the precautions mentioned are still needed.

It is sometimes desirable to mould work, in case of a future demand; but this is not done so often as it might, because the printer does not care to take the trouble of sending the formes to the stereotyper.

Now I want to show you how easy and inexpensive a thing it would be for any printer to mould his formes immediately they come from the machine, and to keep the moulds in case of future need. Here are the formes of a sixteen-page weekly publication, and a set of light metal frames fit in the gutters so as to bring these up to the level of the face of the type. These pieces of flong—each corresponding to a page, with the necessary margin—are rather over-dry than moist, and with them I mould a page at a time, and not many seconds are required for moulding each page, while as each mould is made it is lifted off and set aside. The formes have not even been washed, as the remaining ink does no harm in this case, and the moulds being removed at once, there would be but little risk of adhesion, even if there were not a trace of ink on the type. The damp moulds are now laid between quires of rough paper, this being sufficient to keep them flat during the time of drying, which may be several days. When dry they are stored away in bundles. In casting from one of these moulds a few pieces of old mould are pasted into the hollows at the back, and the brown paper flap is pasted as usual on that edge which is to be the top, but the extra thickness of brown paper at the back is dispensed with. In some newspaper offices it is the practice to take the moulds off some of the earlier pages while wet and dry them separately. When the mould is removed wet there is a contraction of about a one hundred and thirtieth linear.

More or less successful attempts have been made in the direction of moulding the type in a dry and spongy millboard and casting at once, these methods being called instantaneous stereotyping processes—much the same sort of thing as I showed you at the end of my previous lecture—but nothing of this sort has come into general use. The pressure required for a newspaper page would be enormous, and the results hitherto have not been quite satisfactory.

The paper process of stereotyping lends itself very well to the production of plates for printing in several colors, whether for typographic or block work. A series of plates cast in immediate succession, in the same well dried mould, corresponding very exactly; and it is better to cut away from each plate those parts not wanted than to attempt to block them out in the mould, as this latter course may easily lead to distortion. In cutting away the waste metal from the plates, care must be taken not to strain or distort them, and for such a purpose the routing-out tool alluded to is very useful.

The mention of cutting away plates for printing in several colors recalls a use made of stereotypes early in this century by Charles Babbage. He would obtain a number of casts of a block showing a complex machine, and by cutting them away he would produce a separate block showing each important organ of the machine, and these would be printed alongside the complete sketch.

* Such as clean and evenly but slightly oiled original; well united, thoroughly seasoned, and rather dry flong; drying thoroughly in the press with occasional tightening up; long baking of the mould; non-use of French chalk; a suitable hard metal—say the tin alloy given on p. 12366 and this at as high a temperature as the mould will bear; and a considerable "head" and margin of metal in casting, the margin being of the full thickness of the gauges.

† One part of cadmium, two parts of tin, four parts of lead, and seven parts of bismuth.

HAND-POWER DYNAMO.

Those who have to make experiments demanding electric current, and involving the use of half a dozen cells or so, will thoroughly appreciate the advantage of being able to get their small power without having to spend a couple of hours fitting up the cells and looking for binding screws, and two more in washing the cells out when the experiment is over or the cells run down, the latter circumstance being generally the first to occur. We give an engraving of a small hand-dynamo brought out by Mr. H. Austin, of Armley. It is wound to give a large enough output to work a large induction coil, or to light a small incandescent lamp, or, in fact, to do anything for which batteries are at present used in the lecture room or laboratory. The speed multiplication is carried out by friction gear, so as to run smoothly with very little loss of power. It can be fixed temporarily or permanently to any convenient bench, and three leverages or lengths of handle can be got by screwing it on in the different positions shown by full and dotted lines, as shown in Fig. 2.

We wonder some enterprising maker does not bring out a small dynamotor for transforming the power from, say, one large cell giving 2 volts and 50 amperes to 100 volts and 1 ampere. It is not so troublesome to

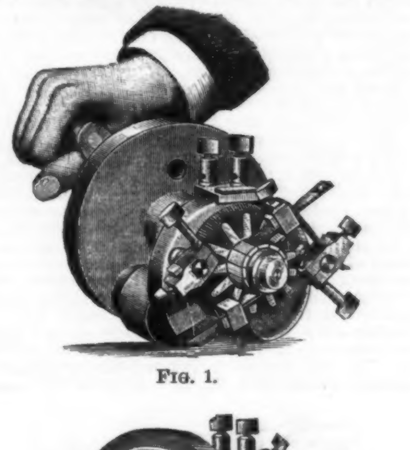


Fig. 1.

Fig. 2.

AUSTIN'S HAND-POWER DYNAMO.

fit up one large cell, and by this means powers too large to be got by hand without fatigue would be easily obtained for laboratory work.—*Industries.*

FRANKLAND'S RESEARCHES ON THE CHEMISTRY OF STORAGE BATTERIES.

The chemical changes which take place during the charging and discharging of storage batteries have been the subject of considerable difference of opinion among chemists and physicists. Some authorities have maintained that the effects are dependent on the occlusion of oxygen and hydrogen gases on the plates, while others, regarding the question from another point of view, have held that lead sulphate plays an important part in the phenomena. That the differences of opinion among experts have been widely divergent may be recognized from the fact that scientists who, apparently, are well competent to express their views have asserted that no chemical change of the lead sulphate occurs either in the charging or discharging of the plates.

In order to test the accuracy of the former opinion, Dr. Frankland, some time ago, undertook a series of experiments, the results of which were communicated to the Royal Society (*vide* Proceedings Royal Society, XXXV., p. 67). Two plates of lead were twisted into a corkscrew form, the gutter of the screw being filled with red lead. These plates were immersed in dilute sulphuric acid and charged in the usual way. When these plates were subsequently heated and the gas evolved, collected and examined, it was found that mere traces of oxygen and hydrogen were expelled, whereas, if the theory had been correct, there should have been a copious evolution. Hence, it was concluded that the important agent in the cell is not constituted by the occluded gases.

With regard to the lead sulphate, Dr. Frankland observed that in charging a strong cell, a considerable amount of sulphuric acid disappears, and is accompanied by a certain deposition of lead sulphate, but that the deposit formed is inadequate to account for the total acid which has disappeared.

The strength of the acid ceases to diminish and afterward increases as the charging of the cell proceeds. This change continues until the maximum charge has been reached, and oxygen and hydrogen gases are

evolved from the positive and negative plates respectively.

When the cell is discharged, the phenomena above described are reversed, the specific gravity of the acid decreasing from the point from which it began to increase on the charging of the cell.

From these experiments and the observations made upon them, Dr. Frankland deduced the following results, representing the changes which occur in *charging* a storage battery, viz.:

1. The electrolysis of hexabasic sulphuric acid (*i. e.*, H_6SO_6) according to the equation

$$H_6SO_6 = \underbrace{SO_3}_{\text{on + plate}} + \underbrace{3O + 3H_2}_{\text{on − plate}}$$

2. The reconversion of the evolved sulphuric anhydride (SO_3) into the corresponding acid (H_2SO_4).

3. Chemical action on the coating of the positive plate according to the equation

$$PbSO_4 + O + 3H_2O = PbO_2 + H_6SO_6.$$

4. Chemical action on the coating of the negative plate according to the equation

$$PbSO_4 + H_2 + 2H_2O = Pb + H_6SO_6.$$

When the storage battery is *discharged*, the first two changes observed in charging the battery are repeated. Further, on the coating of the positive, formerly the negative electrode, the chemical change which takes place is represented by the equation

$$PbO_2 + H_2 = PbO + H_2O$$

on the coating of the negative. Finally, the positive electrode, the change occurring is represented by the equation

$$Pb + O + H_6SO_6 = PbSO_4 + 3H_2O.$$

Hence Dr. Frankland formed the opinion that the formation of the cell consists in the more or less thorough decomposition of those portions of the lead sulphate comparatively removed from the conducting metallic nucleus of the lead. Lead sulphate possesses a low specific conducting power, while lead peroxide, and especially spongy lead, offer comparatively little resistance to the current, which is thus enabled to bring the outlying portions of the coating under its influence.

Since these results were published, Dr. Frankland has been pursuing his researches in the same direction. He undertook a series of experiments with a view to ascertaining what lead compounds actually take part in the chemical reaction in charging and then discharging secondary batteries.

A quantity of lead oxide (PbO_2) reduced to a fine powder was treated successively with portions of dilute sulphuric acid until the liquid became permanently acid. On being allowed to stand, a buff colored precipitate separated from the mixture and was found by analysis to possess the formula $Pb_5S_3O_{14}$.

When finely powdered red lead (Pb_3O_4) was treated in the same way with dilute sulphuric acid, the powder which settled on standing was brownish red in color, and was found on analysis to have the constitution $Pb_3S_2O_{10}$.

Dr. Frankland considers that these hitherto unknown or undescribed salts constitute the original active material of storage cells, and that the following equations accurately represent the reactions which take place on the surface of the plates on charging and discharging the battery:

A. If the buff colored salt is the active material used, then

I. On charging—

(1) Positive plate, $Pb_5S_3O_{14} + 3H_2O + 5O = 5PbO_2 + 3H_2SO_4$.

(2) Negative plate, $Pb_5S_3O_4 + 5H_2O = 5Pb + 3H_2SO_4 + 2H_2O$.

II. On discharging—

(1) Positive plate, $5PbO_2 + 3H_2SO_4 + 5H_2 = Pb_5S_3O_{14} + 8H_2O$.

(2) Negative plate, $5Pb + 3H_2SO_4 + 5O = Pb_5S_3O_{14} + 3H_2O$.

B. If the brownish red colored salt is the active material used, then

I. On charging—

(1) Positive plate, $2Pb_3S_2O_{10} + 2O_2 + 4H_2O = 6PbO_2 + 4H_2SO_4$.

(2) Negative plate, $Pb_3S_2O_{10} + 4H_2 = 3Pb + 2H_2SO_4 + 2H_2O$.

II. On discharging—

(1) Positive plate, $6PbO_2 + 4H_2SO_4 + 4H_2 = 2Pb_3S_2O_{10} + 8H_2O$.

(2) Negative plate, $3Pb + 2H_2SO_4 + 2O_2 = Pb_3S_2O_{10} + 2H_2O$.

It is worthy of remark that in practice only half as much material seems to be necessary for the negative as for the positive plates, and this is evidence in favor of the latter alternative, B, being correct.

We cannot assume, however, that there is nothing more to be discovered concerning the chemical action of storage batteries. The subject is full of complications, and it is to be hoped that electricians will receive further and larger assistance from chemists, who alone, perhaps, are able to throw the necessary light upon these obscure matters.

PROF. OLIVER LODGE, F.R.S.

HE was born in 1851 at Penkhull, a village near the Staffordshire potteries. At eight, in the Newport (Salop), Grammar School, he was thoroughly grounded in the old fashioned manner, with the aid of constant corporal punishment, in the rudiments of Latin, Greek, and mathematics. At fourteen he was put into business with his father in the potteries, and remained there for six or seven years. During this time he informs us that he made his first acquaintance with science by reading an odd monthly number of the *English Mechanic*, and afterward picking up what he could from the articles of the "Penny Cyclopædia." Later, while on a visit to London, he heard a course of six lectures on heat by Tyndall at Jermyn Street, and also attended a private course on elementary chemistry. He then began to attend evening classes in chemistry under the Science and Art Department at the Wedgwood Institute, Burslem; and in 1872 was permitted a winter's course at the South Kensington Chemical Laboratory, on the annual examination list of which he came out bracketed first.

In 1871, by working at odd hours, he matriculated at the University of London, and after two years of private study passed the intermediate examination for a science degree. In this examination he obtained honors in chemistry and physics, standing alone in the first class in the latter subject. He next tried for a scholarship at St. John's College, Cambridge; but, not succeeding in getting nearer than *proxime accessit*, he went to study mathematics at University College, London, where Prof. Carey Foster enabled him to live without much home aid by teaching in exercise classes. In 1875 he took his B.Sc. degree; and the post of demonstrator of physics at University College was created and offered to him about the same time. In the same year he published, in conjunction with Professor Foster, several papers on the flow of electricity in a plane conductor, in which the forms of the lines of flow and equipotential lines are found practically and mathematically for various shapes of conductor, and for different positions of the electrodes.

It was during a holiday visit to Heidelberg in 1876 that he read and analyzed the first volume of Maxwell's Electricity, and the same year he exhibited before the British Association a model consisting of a string on which are threaded, either loosely or rigidly, balls attached by elastic bends to fixed supports. The various parts of the model each represent some electric property, and its purpose was "to illustrate mechani-

cally the passage of electricity through metals, electrolytes and dielectrics, according to Maxwell's theory."

In 1877 he became assistant professor of physics at University College, and undertook lecturing duties. He was also lecturer in physics at Bedford College, London. Afterward in addition to these appointments he assisted the late Prof. W. K. Clifford in the Mathematical Department of University College.

In 1881 Dr. Lodge was elected to the Professorship of Physics and Mathematics at the new University College, in Liverpool.

All of Hertz's experiments have been repeated at Liverpool, and last year two pitch lenses were cast in order to verify that the laws of refraction of electric waves are the same as those of visible light. Since then Prof. Lodge has attempted to account for the action of the eye by supposing transverse oscillations to take place in the rods and cones, and he has even gone so far as to construct an artificial "electric eye" to illustrate his views. Oscillators for producing electric waves have been made by him of all shapes and sizes, giving waves from one inch to 2,000 miles in length. Indeed, during the past three years the lecture theater of the college at Liverpool has constantly been adorned by a maze of wires for experiments.

Some idea can be got of his activity from the fact that Prof. Lodge delivers on an average ten or twelve lectures weekly during eight months of the year. But this is not all. He is a member of the council and of the library and building committees of the college, and in the case of an institution growing so rapidly as that at Liverpool, these take up a considerable amount of time.

He is also one of the examiners in sound, light, and heat for the government science and art examinations, and has just been elected an examiner in physics at the University of London, having previously (1876–79) held the post of assistant examiner. As professor at one of the three constituent colleges he is also an examiner for Victoria University.

The clear, terse way in which Dr. Lodge sets forth his ideas and describes his experiments has awakened in the minds of many an interest in his work which the ordinary theorist finds himself unable to create. This lucidity of statement contributes greatly to his success as a controversialist, while in his college lectures it is especially felt and appreciated. Moreover, it makes him welcome everywhere as a writer or lecturer on scientific subjects. His scientific researches are very numerous.

For the foregoing abstract and for our portrait we are indebted to *The Electrician*.

PHOTO-ETCHING UPON COPPER PLATES.

THE time has now arrived when amateurs are beginning to try their hand at working the quasi-secret processes of photo-gravure. These processes are fundamentally the same, although many variations of it are practiced. Without doubt photo-gravure possesses advantages over all other photo-mechanical printing processes for artistic reproduction, but is of course more expensive, as each individual print costs an appreciable amount, thereby differing from photo zincs or blocks made in a similar way for quick printing purposes. Being an intaglio process, it is of course quite impossible that prints can be taken with the type for book illustrative purposes. The object of this article is to point out an easy method by which a copper plate can be etched and one in which not much apparatus is required. It will scarcely be necessary to remind the reader that an intaglio plate is the very opposite of a type printing block, the high lights being elevated and shadows impressed in the plate, whereas in a type printing block the shadows are the portions in relief, the high lights being recessed. In the former the plate is inked and then more or less of the ink is cleaned off, leaving that of the half tones and deep shadows, while in a type printing block the roller, which is charged with ink, only impinges upon the parts in relief, leaving the recesses untouched. The relief is very slight in an intaglio plate, as the paper has to be pressed into the hollows in order to pick out the thick, glutinous ink which they contain.

It seems to have been the object of most writers on this subject to impress upon their readers the great *difficulty* of the process, which may perhaps be explained by the fact that many have made their livelihood by it, and therefore were interested in keeping amateurs out of the field.

The apparatus required is not extensive, the following being the absolute requisites:

1.—A negative *worth* producing, and a good transparency made from it.

2.—A carbon print made from this transparency.

3.—A dusting box to put the ground upon the plate.

4.—A flat metal plate which can be heated underneath with a gas stove, and a pair of pincers.

5.—Copper plate, cleaned thoroughly, for etching upon.

6.—A quick-drying varnish to protect the edges of the copper plate.

7.—Biting fluids of various strengths.

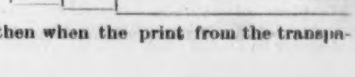
8.—A copper plate press, with blankets.

9.—Prepared whitening or French chalk, ink, dabbers, buff leather.

10.—Last, but not least, a knowledge of copper plate printing; undoubtedly this last item is the most difficult to obtain.

The only apparatus that calls for any special description is the dusting box. Our own being very simple, and such as any person can make for himself, we will describe that: It consists of a tall box, 18 inches high, 8 inches wide, and 6 inches deep, lined throughout with a *glazed* paper, to prevent the resin sticking to the tops and sides. It has a slit opening about two inches from the bottom of the box, about two inches wide, running from one side of the front to the other. A strip of brown paper is cut 3 inches wide and 12 inches long, and this is glued at one end to the side of the box, so that it can be brought round the front of the box to close the slit in front, and fastened by means of a pin, or otherwise, at the opposite side. Two stout copper wires are now stretched across the box at the level of the lower margin of the slit, running from side to side of the box, forming a false bottom upon which the plate can rest during the time when the grain is being put on the plate. This, with about a quarter of a pound of *finely powdered* resin, completes the dusting box.

The transparency can be made by any of the processes in vogue, collodio-bromide, wet collodion, carbon or gelatine The great thing to be remembered is that the high lights ought to be carefully preserved free from fog. The transparency should be a reversed one, should the print be desired to appear as in nature, the reversing of course being done most easily by copying the negative through the glass, that is, placing the film furthest away from the lens in copying. This transparency must now have a *safe edge* put upon it, which can be done by cutting strips of black paper with clean-cut edges upon the *back* of the plate, masking out the picture to the shape required, taking care to get the angles *true*, as the margin of the finished print depends a good deal upon the way in which this safe edge is applied. Safe-edging may be done, if preferred, by cutting a mask out of semi-transparent paper and placing this on the film side of the transparency, that is, between it and the carbon tissue. The carbon tissue ought to be fresh and in good condition for the next part of the process. It is best to buy it direct from the Autotype Company, ready sensitized, as they send it out fresh twice every week in any desired color. It remains in good condition for a week or ten days. *Standard brown* is the best color to use, as the process of etching can afterward be better seen through it. The exposure of the tissue is about the *same* as for silver paper (albumenized). We expose a piece of silver paper behind the transparency until we get a good negative, exposing at the same time a strip under a home-made sensitometer, made of a number of pieces of paper superposed upon each other, each being about a quarter of an inch shorter than the one below it, thus:



By noticing then when the print from the transpa-

rency looks about right, and noting the number visible on the strip under the sensitometer, one always prints the carbon tissue until that number again appears in the sensitometer strip. The advantage of this form of sensitometer is that odd strips of albumenized paper can be used up in it, and it is therefore more convenient than the square form.

The copper plate must now be prepared to receive the provisional image. The plates as bought are planished, and have a finely polished surface upon them, but usually want cleaning, which is done with finely powdered French chalk and water, and a soft leather, giving a circular motion when cleaning. The French chalk must be free from grit, which would scratch the plate. The plates should be thick, as then, should any mistakes be made in the biting, the surface can be taken off and the plate repolished.

After having been cleaned, they are ready to have the grain or ground put upon them. To do this the dusting box is taken, and the finely ground resin is shaken up in it, the box then placed on the table, and the top and sides are tapped with the fingers to shake down any particles which might have adhered to them, and after allowing about a quarter to half a minute for the coarser particles to settle, the clean copper plate is inserted through the slit in front, and is laid upon the two horizontal copper wires face upward, and the flap of brown paper is now brought round to close the aperture through which the plate was inserted. The box has now got an atmosphere of fine resin dust, which slowly settles on the plate, and if this be removed carefully, after having been in the box about four minutes, it will be found to be coated over with a beautifully even coating of resin. Should this not seem sufficient, the box can be again shaken and the plate reinserted. When sufficient is on the plate, the surface of the copper can *just* be seen through the resin. The plate is now grasped by the pincers and placed on the metal plate, which is heated from below with a gas stove. If the metal plate cannot be obtained, heat over the gas stove, giving a circular motion so as to heat the copper plate as uniformly as possible. The heating is continued until the resin *just*, and only *just* melts, which can be seen by a wave of dark color passing over the film; directly this has gone over the plate, put it down to cool. Now take the carbon tissue (which we presume to have been printed) out of the frame, but not before a pencil line has been drawn along the paper side of the tissue, to mark the actual edge and corners of the picture, as the image being invisible if this precaution is neglected, it is very probable that when developed the image will be found crooked on the plate. It is also as well to mark the top of the picture. The tissue is now placed in a dish of cold water and the air bubbles are brushed from the surface. It will first curl up and then uncurl again. When uncurled it is ready to be put, surface downward, upon the copper plate, so that the picture is "true" with edges of the copper plate; then it is firmly but not too violently squeezed, so that it is forced into contact with the resin grain. Too much energy must not be expended lest the tissue should be torn, as it becomes tender during the soaking. And now the plate is reared up to partially dry. In about ten minutes take a dish and some warm water about 90-100° Fahr. and place the plate, with the carbon tissue in contact, into the warm water, removing the air bells from the back of the paper with a brush.

As soon as the pigment begins to ooze from under the edges of the carbon tissue, raise one corner with a pin and tear off the paper and keep splashing the warm water upon the image. The pigment that was contained in the gelatine unacted upon by light is now washed away, and the other portions remain behind. The warm water ought to be changed, and the temperature slightly increased toward the end, bearing in mind that the copper in the portions which are to represent the deep shadows should be quite clean, as should be the edges of the plate. The development should last about five minutes; when finished the image appears as a negative on the copper—in relief. The copper is now immersed in a 5 per cent. sol. of alum to harden the film. It is kept in the alum bath about twenty minutes, after this it is washed and put to dry. The drying was in our case the first difficulty which was encountered, it being almost impossible to completely dry the film without its splitting from the copper. Quick and slow drying were both tried, but the result was always the same, the film split, often bringing the part of the graining away with it. The plates were put into a rack, and just as the lowest corner was drying the film came away. After this we tried drying in a horizontal position by means of warm air, and have never had an accident since this proceeding was adopted. The horizontal position has more to do with success than the warm air, as in that position various parts of the film dry at the same time, whereas when put into an upright rack the lower corner was always the last to dry, and in doing so exerts sufficient tension on the dry film to bring it away.—*Victor A. L. E. Corbould, in the Photographic Art Journal.*

MUSICAL INSTRUMENTS IN THE NEW HEBRIDES.

THE natives of the New Hebrides, who are still addicted to the practice of anthropopagy, afford us one of the most curious subjects of contemporaneous study to be made upon primitive and savage populations. We borrow the accompanying illustration from a memoir published in Hamy's *Revue d'Ethnographie* by Dr. A. Hagen, of the navy, and Lieutenant of Marines A. Pineau. This engraving represents hollow tree trunks containing apertures connected by a vertical slit. These trunks are ornamented at the upper part with sculptures representing heads, feet, war clubs and ships. By striking each of them with a stick, the natives produce somewhat cadenced sounds resembling those of the tom-tom. They perform their dances to the sound of these instruments, after having daubed their faces with red and black. They have also three other musical instruments: a sort of trumpet made of a shell perforated at the side or extremity; a syrinx with six, seven or eight pipes, from which they sometimes obtain harmonious sounds; and a long flute perforated at the lower extremity and consisting of a single piece of bamboo with three holes and a mouth piece. These instruments are used only within doors in order to amuse children.—*La Nature.*

USE OF THE PHONOGRAPH AMONG THE ZUNI INDIANS.

By J. WALTER FEWKES.

EVER since I began my work with the phonograph as a means of preserving the language of the American Indians, I have looked forward with great interest to a visit to some of those tribes which still remain in approximately the same condition that they were when first visited by white men. Such tribes it is almost impossible to find now in the confines of the United States. But there are some which have been very little changed.

I have been particularly anxious to make observations among the Pueblo Indians, who still possess many interesting features of great antiquity. Of all the Pueblos, except possibly the Moquis, the Zunians, or A'sheewee as they are called in their own tongue, have been least changed from their original condition by contact with Europeans. Living at a distance from the railroad, inhabiting isolated regions difficult of access, these people have preserved the ancestral traditions and customs in their primitive form. In many ways they offer an unparalleled opportunity for the study of the religious and secular celebrations of Pueblo Indians, slightly modified from the olden time.

A previous visit to Zuni, in the summer of 1889, had inspired in me a wish to attempt to record on the cylinders of the phonograph the songs, rituals, and prayers used by these people, especially in those most immutable of all observances, sacred ceremonials. I was particularly anxious to record the songs connected with the celebration of the midsummer dances, which occur at or near the summer solstice. By the help of Mrs. Hemenway, of Boston, it was possible for me, in the interest of the Hemenway expedition, to visit Zuni Pueblo at this time, and I have been fortunate enough to take on the phonograph, from the lips of the Zunians, a series of records illustrating the songs used in take part, or to let them know that exercises are in progress, for which purpose its use was not unknown among the ancient Greeks.

Four days before the dance, on the afternoon before the departure of a delegation of priests to offer feather plumes at the "Sacred Lake," Tay jay po une, a ceremony takes place in the Pueblo, which may be called the "Ducking of the Clowns." This observance is known to the Zunians as the Dumachimche, from the words of the song by the Ko ye a mashi, or mudhead clowns, on whom, in the course of the celebration, water is poured from the housetops by the squaws. This song has internal evidence of antiquity, and I am told by the Indians that both song and ceremony are very ancient. Although a musical critic might not find in it great beauty, as an undoubted specimen of ancient aboriginal music it is very interesting. I shall comment on the meaning of the Dumachimche in another place, when the ceremony will be described at length.

A survival of the old practice of communal hunting still exists in some of the Pueblos in the so-called rabbit hunt. Several of these hunts have taken place during my residence in Zuni. It has seemed to me that it is a semi-religious observance connected with summer dances, and I have, therefore, taken records of the song and prayer used by the hunters for future study.

While my observations have been particularly directed to the linguistic features of the solstitial dances in summer, I have not wholly neglected the great wealth of other material all about me for linguistic study by means of the phonograph.

The well known celebration called the Sha' la 'ko, at which the Zuni house is consecrated, is the occasion of an elaborate ceremonial, in which figures a song or chant and a prayer, said to be very ancient. I have never witnessed the celebration of the Sha' la 'ko, but have been able to obtain the chant and prayer from one of the natives. This capture had to be made secretly, unknown to the other Indians. It was found

MUSICAL INSTRUMENTS OF THE NEW HEBRIDES ISLANDERS.

necessary to take it late at night, in a room darkened with blankets at the windows to prevent suspicion, and sentinels stationed about the house to warn us of the approach of intruders. On those conditions only was it possible to get the Indian to chant the Sha' la 'ko on the phonograph. It is now, however, permanently recorded in the wax, and can be reproduced at pleasure, or, what is of more importance to philological study, can be written out and studied at leisure under better conditions. I am told that it is next to impossible to get any of the Zunians to sing the Sha' la 'ko out of season, and as the celebration regularly comes in November, a record of it in July is a fortunate acquisition. Certain of their winter songs they will not sing in summer, because to do it prevents the corn from growing. I do not know whether or not the chant of the Sha' la 'ko is one of these.

The phonographic record to which I look forward with the greatest hope is that of a Zuni ritual to which writers have from time to time referred. This ritual, which has been designated by the dignified title of a Zuni epic, is of considerable length, and is regarded with great reverence by the Zuni people themselves. Halnta, the reciter of it at the time of its delivery, is said to be regarded as a most sacred personage, and when, prior to its recital, he is brought into the Pueblo, his feet, it is said, are not allowed to touch the ground. It is thought probable that a phonographic record of the ritual would be an addition to our knowledge of Zunian mythology.

The extracts from this ritual, which are freely translated from memory by Mr. Cushing in his interesting paper on Zuni fetishes, indicate that it is a valuable account of the mythological history of the race. He had not at his command an instrument to record the words of those portions of the "Kaklan" which he heard, and consequently was unable to give it in the original diction in which it is given before the members of certain priesthoods, to whom alone it is recited. He says that many of the words are in old Zuni, not understood at present. The records which I have are good enough to enable me to write out the ritual, which, however, at the present state of my knowledge of the language I am unable to translate. With the help of those who understand the language, as well as English, I have no fear but that in my final paper I

their sacred and secular observances. An extended paper, with illustrations of the dances, has been prepared for publication, and will be printed as soon as the music can be written out by an expert from the cylinders of the phonograph. Although I prefer not to publish my final contribution until the illustrations are prepared from my photographs, a brief notice of some of the phonographic records which I have may not be without interest.

One of the most interesting of the songs sung at this dance, which is called the Kea' kok' shi or good dance, is that of the Ko ko. This song I took directly from the lips of one of the participants in the dance. I have reason to believe that this song is improvised each year, as the music this summer is quite different from that of a year ago. I was told by the Zunians before the dance that they did not know what the song was to be, and that no one knew except the participants. There is, however, a general resemblance, yet still great variety, in all these "Ko ko songs," and I have indelibly taken on phonographic cylinders as many as possible for a comparative study at a more favorable opportunity.

The possibility that the songs of the Ko ko were originally imitations of the wind blowing down the fireplace or around the house is a fascinating idea which hardly seems capable of proof or the contrary. There are often strains in the Ko ko songs that remind one of the wind, and it is rightly appropriate that such imitations should occur in dances instituted for rain, which is ordinarily associated with the wind. At this place it may be well to mention the fact that there is introduced into the dance an implement to imitate the wind. On the entrance of the Ko ko into the Pueblo, and during the dances, the clowns or other persons, generally the clowns, have a small stick fastened to a buckskin thong, which they whirl about in a circle, making the sound of the wind. This implement, which is the exact counterpart of the "bull roarer," so well known to boys in some English communities, is called the wind. I cannot discover that it is used in the sacred ceremonies to frighten the women and children, or those who do not take part in the dance. Sometimes it is even used as a plaything by the Zuni boys. In Australia an instrument almost exactly similar is used in sacred ceremonies to frighten those who do not

can publish a translation of the ritual as told by Haluta on the cylinder of the phonograph.

I have, after several failures, been able to get this recital on the phonograph, where it fills a long series of cylinders. Before the value of this record, both linguistic and mythological, can be appreciated, it must be carefully written out and studied. This will take a long time, as many of the words are old Zunian, and the task of extracting the meaning from the ritual will be found to be a difficult one. A permanent preservation of it is, however, a step in the interpretation, and when once indelibly fixed on phonographic cylinders its true character and significance can be investigated.

One of the most interesting of the Zuñi songs is that of the hunters. This song has many beautiful parts in it, and outside of its interest in the study of the customs of the hunters, is well worth preserving as a specimen of aboriginal music. I have thought it worthy of a place in my collection, and with it I have also preserved certain of the prayers to the fetishes used in the hunt, some of which have been written out and translated by Mr. Cushing. The harvest which a study of the hunting customs of the Zunians offers is great, and the collection of data bearing on this subject is highly important, since the decrease in game may go on as New Mexico is more and more thickly settled, and the hunting ceremonials be more or less modified as time goes on.

I have not encountered, in my experience in taking records with the phonograph, any very great difficulty among the Zunians. Their real impressions of the instrument it is very difficult to divine. One of them asked if a person was hidden in the machine, and another thought the phonograph bewitched. Indians are so stolid that it is very difficult to discover what impression such a novel instrument as the phonograph really makes. They are so accustomed to incomprehensible machines used by Americans that this last triumph of inventive genius affects them no more than many others which might be mentioned. Certainly they are not afraid of it, and there is no difficulty in getting them to talk into the instrument. The great difficulty in getting them to repeat their sacred songs and prayers does not come so much from their fear of the instrument as of secularizing what is sacred to them. They will readily respond with any of their secular songs, or with those sung in public, but those belonging to the secret ceremonials of the Estufa they will not divulge.

Zuni, New Mexico, July 5, 1890.

—*American Naturalist.*

ORCHIDS IN PANAMA.

THE average amount paid for newly introduced orchids varies from 10 to 25 cents each, if bought by the thousand. At this and even lower figures most of the species of orchids are procurable. A higher price for a single plant is paid only if it is a new, or at any rate, very rare or peculiar variety, that may exist only in one specimen. It is, therefore, very seldom the floral value of an orchid that is honored with such fancy amounts as from £100 to £250 sterling, but in most cases the rarity only. For to make out the best profits of these (very often would be) new varieties, they are beautifully illustrated in costly but from a scientific point of view of little merit works, and named in honor of well-paying wealthy men, such as Baron Rothschild, Baron Schroder, Sir Trevor Lawrence; while the names of Sander, Stevens and other nurserymen and auctioneers are found scattered about in literature of this kind in great profusion—and accompanied by flattering descriptions, in which, as leading features, great care is taken that the full names and addresses of the lucky owners or speculators are conscientiously given. Notes on points such as the native country of the plant, the physical conditions under which it grows there, the names of the real discoverers, etc., are often omitted. From a scientific as well as from an ideal point of view, this procedure is to be greatly reprehended; in the first instance, because it confuses and fills the literature of botanical science with straw without grain, and in the second because it degrades to the profanest materialism one of the noblest sentiments in human nature—the love of flowers.

Among the orchids growing on the Isthmus of Panama, there is none that might fetch anything like such a fancy price as indicated above. No one, therefore, need build palaces of illusion on the supposed "riquezas" hidden in the mountains or woods difficult of access. But the real business man never does this; he bases his operations on mathematical deductions, and if he can see that upon his investment of capital and labor a profit will result, it is then a business worth while entering upon. And from this point of view (and from this alone) a comparatively large number of species of orchids growing on the Isthmus may be utilized. In explanation we will enumerate those species which, from such a commercial point of view, are noteworthy.

1. The genus Selenipedium. Of this genus grow three species on the Isthmus, viz., S. caudatum, S. longifolium, and S. chica. Of these, S. caudatum is the most valuable. It grows in the mountainous regions of Chiriqui and Veraguas at an elevation from 1,000 to 1,600 meters. It is a rarely occurring kind, and not a very good traveler. The other two species have a greater botanical than horticultural value. Notwithstanding this, S. longifolium is often cultivated as a curiosity or ornamental plant.

2. The genus Cattleya. Of this only two species are found on the Isthmus, viz., C. Dowiana and C. Skinneri, of which the former is the rarest, most valuable, and at the same time one of the finest cattleyas known. It was named in honor of Capt. J. M. Dow, the venerable gentleman so well known to all residents of the Isthmus, in grateful recognition of his many services rendered to scientific travelers who visited Central America in former years, and his own well known and highly appreciated scientific researches. C. Dowiana inhabits the northern and northeastern districts of the Isthmus, extending from Costa Rica—slopes of the volcano of Torralba—to the departments of Cauca and Antioquia, and a region from the sea level to 500 meters above it. The variety growing in the department of Antioquia and Cauca is called C. Dowiana aurea on account of its lighter colored flowers. A peculiar variety of somewhat smaller development was found in the vicinity of the Rio Taira, in the Darien, in 1879. The other species, C. Skinneri, is only met with in Chiriqui and Veraguas, at an elevation of 600 to 1,500 meters, extending from there into Central America, as far as Guatemala. It is a very floriferous and fine orchid, though a cheap one, owing to its great abundance and wide distribution. A variety with pure white flowers was first discovered in the vicinity of Torralba, and is now carefully cultivated and multiplied in Costa Rica. It is a very valuable orchid.

3. The genus Epidendrum. The species of this genus are distributed in a large number over the Isthmus, of which a few are of commercial value. These are E. prismatocarpum, growing in Chiriqui and Veraguas at 1,000 to 1,500 meters; and E. marcochilum, found all over the Isthmus near the sea coast. E. Stamfordianum also is an exportable kind, though less highly priced than the former.

4. The genus Odontoglossum. Several of the members of this genus are, next to Selenipedium caudatum and Cattleya Dowiana, the most highly priced orchids of the Isthmus, and one species, viz., O. Warscewiczi, is exclusively found in this State. It grows at the higher regions on the mountains of Veraguas, from 1,400 to 1,800 meters. From a floral point of view, it is one of the loveliest orchids known. It is a rare and very difficult kind to export. The other species of this genus growing on the Isthmus are: O. Roezli, O. Krameri, O. Schlieperianum, O. cariniferum, and O. pulchellum. All of them are valuable plants, and will pay for exporting. With the exception of O. Roezli, which is found near the coast of the Darien, they all grow in Chiriqui and Veraguas, from 1,000 to 2,000 meters elevation.

5. The genus Oncidium is of most common occurrence on the Isthmus, and represented in about ten species. Of these, however, only three or four are of commercial value, but of secondary importance. The two best are O. cheirophorum and O. fuscatum, or Warscewiczi, both from Chiriqui and Veraguas. The other species of interest are O. ampliatum, found everywhere in the warmer region; O. ornithorrhynchum, on the volcano of Chiriqui; and O. altissimum, on the savannas round David.

6. The genus Trichopilia, though not a very showy orchid, is represented in three very fine species on the Isthmus. These are T. suavis, T. coccinea, and T. crispa, all growing in Chiriqui and Veraguas at an elevation of 1,000 to 1,500 meters.

7. The genus Zygoptalum with its two species, Z. cerinum and Z. discolor, both from the volcano of Chiriqui, 800 to 1,400 meters, conclude the number of valuable orchids, of those at any rate which always can be sold to some extent.

There grow, however, still several other species of orchids on the Isthmus, which from time to time may be sold on a small scale also, but these are mere curiosities, or of scientific interest. The principal species belonging to this group are: Catasetum chrysanthum, C. naso, Peristeria elata (known to Isthmians by the name of "Espirito Santo"); Brassavola albida, Aspasia spec, Rodriquezia secunda, Notylia replicata, Notylia albida, Jonopsis paniculata, Masdevallia atenuata, Masdevallia Livingstonei, and a few others.—*Panama Star and Herald, Aug.* 8.

BRANCH AND FRUIT OF THE BLACK PEPPER VINE.

THE BLACK PEPPER VINE.

BLACK pepper is a condiment that has been held in the highest esteem from the earliest times. It is frequently mentioned by Roman writers of the Augustan age, and it is related that in the fifth century, Alaric demanded, among other things, 3.000 lb. of pepper in ransom for the city of Rome. The plant from which this condiment is obtained (Piper nigrum) is cultivated in the East and West Indies, Sumatra, Java, etc. The pepper vine will, if left to itself, attain a height of twenty or more feet, but in cultivation it is found more convenient not to allow it to exceed the height of twelve feet. The plants are placed at the base of trees that have rough or prickly bark, in order that they may the more readily attach themselves to the trunk. In three years they produce their spikes of fruit, and continue to do so for some seven or eight years, after which time they become less productive. The fruit, when ripe, is of a red color. It is gathered before it is fully mature, and spread upon mats in the sun, when it loses its color and becomes black and shriveled, as we see it in the pepper corns of the shops. This is black pepper. White pepper is the same fruit freed from its outer skin by maceration in water and subsequent rubbing. It is sometimes rendered of a still paler color by exposure to the action of chlorine. The finest white pepper comes from Tellicherry, upon the coast of Malabar. The most important points of its preparation are the establishments of the Straits, which annually export from 2,000,000 to 2,500,000 pounds of it. Most of this spice goes to China, where it is held in high esteem.

In Europe, during the middle ages, pepper was the most highly esteemed spice, and Genoa, Venice and the commercial cities of the center of Europe are indebted to it for a part of their wealth. Its importance as an object of commercial exchange, during the middle ages, and consequently as an element of civilizing relations between nations, was so great that it can scarcely be exaggerated. Taxes were levied upon it, donations were made of it, and it was often used for exchanges at times when money was scarce. Black pepper is exported into Europe and America in enormous quantities. Aside from its use as a condiment, it is employed in medicine as an acrid stimulant in cases of weak digestion, and it has also been recommended in cases of ague to ward off the paroxysm. Pepper is also sometimes employed externally. Upon chemical analysis, it is found to contain a hot acrid resin and a volatile oil, as well as a tasteless crystalline substance called piperin, which has been recommended as a substitute for quinine.

The different varieties of pepper met with in commerce bear the names of Malabar, Cochin, Aleppo, Penang, Singapore, Siam, Cochin China, and Sumatra.

THE FILTRATION OF NATURAL WATERS.*

By THOMAS M. DROWN, Member Boston Society Civil Engineers.

IN the study of the subject of filtration of water for drinking purposes, we shall arrive at no clear and valuable ideas unless we distinguish sharply between mechanical filtration, which deals only with the interception and retention in the filter of the solid particles suspended in the water, and filtration combined with the oxidation of organic matter—that in solution, as well as that in suspension in the water. This latter process—the purification of the water by the oxidation of its organic contents—can be accomplished only by *intermittent* filtration; the former—the mere removal of the solid particles in the water—may be accomplished by *continuous* filtration, as practiced in many large cities in Europe.

When we speak of the purification of water by filtration, we mean in a general way that a water is thereby rendered fit to drink which was unfit or unattractive before it was filtered. The change effected by filtration may be simply the removal of vegetable or earthy matters, whereby the water is made more palatable and more attractive in appearance, or it may be more radical in converting water which was positively harmful into a good drinking water. Widely different in action as are the two systems of filtration, the intermittent and the continuous, yet it is possible by both systems to improve the quality of a bad water.

In the system of continuous filtration, in which there is little or no change made in the dissolved organic matter, it might at first thought seem as if there could be only imperfect purification; but it must be borne in mind that it is possible in this system to remove in great part even those very minute organisms, the bacteria.

The germ theory of disease furnishes us with the simplest explanation of the way in which water does harm, and if we can, by simple mechanical filtration, remove the harmful germs from the water, we have effected a true and efficient purification of that water, whatever may be its chemical composition. Let us push this idea a little further. If we take as the basis of our theory of harmfulness of water that disease is caused by it only when micro-organisms are present in it, then, if we could by the continuous filtration of sewage remove absolutely all the germs which it contained, leaving unchanged its other characters, appearance, taste, odor, etc., this sewage would be perfectly safe to drink. To put the matter in another form, a sterilized water or sewage has no possibilities of producing disease except so far as it may contain saline or other substances which may produce derangements of the system in the same way as would a drug, a dose of salts or of senna. It is foreign to my present purpose to consider whether our knowledge at present justifies this position, but it is important to bear it in mind in judging of the efficiency of filtration.

When water is said to be well, or moderately well, or completely purified by filtration we cannot know what is meant unless we know what is the standard of purity implied. Is it simply the removal of color, odor and suspended matter; is it chemical purity, meaning thereby the absence of unoxidized organic matter, or is it bacterial purity, or freedom from germs? Again, what shall we say of water of high chemical purity, with high bacterial contents, or what of a water with few or no bacteria which contains considerable organic matter capable of undergoing change?

Intermittent filtration is capable of giving water free from organic matter and free from germs; continuous filtration, if conducted very slowly, is capable of giving water free from bacteria, without odor and color, but which may contain much dissolved organic matter. Intermittent filtration effects the oxidation of the organic matter in solution as well as that in suspension; continuous filtration has little or no effect on the organic matter in solution.

After laying such stress on the removal from water of bacteria, it sounds like a paradox to say that purification both by intermittent and continuous filtration depends on the presence in the filter of bacteria in enormous number, and that without them the purification would in both cases be impossible.

The idea is not a new one that the bacteria of decomposition are benign and useful organisms which break up organic matter, rearrange its atoms and convert it into mineral matter so that it may again serve as food for plants. If we keep away the bacteria from a mass of dead organic matter, it undergoes

* Read January 15, 1890.

no change whatever. All processes of decay of organic matter are absolutely dependent on the presence of these micro-organisms, which, so far as we know, have no other than a benificent role to play in nature. I say this is now a matter of common knowledge, and one is therefore not unprepared to hear that in the purification of water by intermittent filtration the ground or sand upon which the water is poured is full of bacteria; in fact, that it is the design of the process to cultivate them and have as many of the micro-organisms in a cubic inch of ground as possible.

If one pours over a column of clean, bright sand, free from bacteria, impure water, as sewage, it will flow out about as bad as it entered the sand. But if it is poured over a column of sand in which septic bacteria have been cultivated, so that the sand may be said to be fairly reeking with bacteria by the million, the water may flow out as pure (organically) as spring water. But even in continuous filtration, where there is little or no oxidation going on, the bacteria are, according to Piefke (the engineer of the Berlin water works), the efficient agents in removing the suspended matters, including the micro-organisms in the water. To this subject we will return later; let us first briefly study the nature of oxidizing or intermittent filtration on the typical polluted water, namely, sewage.

Sewage is a substance which contains all of its nitrogen in the unoxidized form. Its principal ingredient is free ammonia, it also contains considerable (but a much less amount, usually) organic nitrogen, or albuminoid ammonia, but of nitrous or nitric acid it contains none. When sewage is exposed to the air in mass, oxidation goes on very slowly, because it can only get air from its surface; when it flows out into streams, the oxygen dissolved in the water of the streams quickly oxidizes the ammonia, and we find in the water, a short distance below the entrance of the sewage, nitrites and nitrates abundantly. When the sewage is exposed to the air in very thin layers, as when a porous material like sand is moistened with it, oxidation goes on with great rapidity. It was until recently considered that this oxidation was a direct chemical combination of the elements of the organic matter with the oxygen of the air, or the oxygen dissolved in the water, but we now know that nitrogen is not oxidized by the direct contact of decomposing nitrogenous matters with air, unless bacteria are present, and the inference seems a fair one that the greater the number of bacteria the more rapid the process of oxidation. Sewage itself usually contains hundreds of thousands of bacteria to the cubic centimeter, which are dormant until air gets access to it. If sewage is preserved out of contact of air, the bacteria of decomposition will in time all die.

The experiments of the Massachusetts State Board of Health on the purification of sewage by intermittent filtration, which have been carried on at Lawrence for the past two years, under the direction of Mr. Hiram F. Mills, the engineer member of the board, have added largely to our knowledge of the conditions governing the purification of nitrogenous organic matter. Here are large tanks $\frac{1}{200}$ of an acre in surface, filled with different materials—coarse sand, fine sand, river silt, muck, garden soil, clay, etc., to the depth of five feet, on which is poured from day to day sewage in known amount and of known composition. The effluent water from this sewage filtration is collected, measured and analyzed and the precise amount of purification determined. The result of two years' work at this station will shortly be published in the report of the board now in press. I will at present give one or two of the facts that have been there developed. The purification of the sewage means the complete oxidation of all its organic ingredients, both in solution and in suspension, the carbon to carbonic acid, the hydrogen to water and the nitrogen to nitric acid. The filtering materials best adapted to the purpose are those which are fine enough to retain considerable sewage in their pores and also plenty of air at the same time.

The body of porous material is, when in good working order, a very delicate machine. It must be coaxed up to its highest efficiency by gradually increasing the amount of sewage. This means, in all probability, that we must develop in the pores of the sand an immense number of bacteria to be constantly on hand in the different layers to attend to the sewage as it reaches them. During the first winter there was no nitrification in these tanks and consequently no perfect purification, but on the advent of spring, when the temperature of the effluent water reached 39° F., nitrification began, and has continued ever since, the cold weather of the second winter failing to stop it.

The tank which has given the best results, that is a good purification of the largest quantity of sewage for a long period, is filled with coarse mortar sand, most of the grains of which average about 0·06 inch in diameter. This has given an effluent day after day organically as pure as many drinking waters, when receiving sewage at the rate of nearly 60,000 gallons per acre per day.

One would naturally ask why is not this the ideal system of purification of all surface waters, even those that are not polluted by drainage of any kind, but which contain much vegetable suspended matter, and have, in consequence, sometimes, a bad odor; or waters which are unattractive in appearance by reason of dissolved coloring matter?

One of the tanks of the Lawrence Experiment Station has filtered Merrimack water intermittently for more than two years at the rate of 300,000 gallons per acre per day. The filtering material consists of 3' 8" of coarse and fine sand and fine gravel; 10" of yellow sandy loam, and 6" of brown soil in the same position as found on the river bank. During the day the surface of the sand is generally covered with a few inches of water, but at night and on Sunday air gets access to the sand. The following table gives the composition of the filtered water during last December, compared with the Merrimack water applied.

	Merrimack River water. Parts per 100,000.	Filtered water. Parts per 100,000.
Turbidity	very slight	none
Sediment	very slight	none
Color	0·35	0·0
Odor	faintly vegetable.	none
Total solids	4·2	3·5
Loss on ignition	1·6	0·9
Free ammonia	0·0015	0 0005
Albuminoid ammonia	0·0127	0·0059
Chlorine	0·18	0·18
Nitrogen as nitrates	0·0124	0·0191
Nitrogen as nitrites	none	none

The water is free from microscopic organisms, and the bacteria rarely exceed 10 or 20 per cubic centimeter, while the water applied has generally a few hundred. During the two years that this tank has been in operation the surface has not been cleaned or disturbed in any way. The slow rate of filtration (being only about one-half an inch an hour per square foot of surface) is due to the considerable amount of very fine material contained in the soil and loam.

But one must bear in mind, in connection with the rate of filtration, that the thoroughness of the purification, meaning thereby the oxidation of the organic matter, is much greater in intermittent than in continuous filtration.

This system of intermittent filtration for natural waters has never, I believe, been carried out on the large scale, although the possibility of its being practicable in some localities has been discussed. It is the system that nature suggests, for it is intermittent filtration which supplies the springs which furnish the ideally pure and perfect drinking water. In the report of the Massachusetts State Board of Health to the Springfield Water Board, with regard to the purification of the water of its Ludlow reservoir, which contains an immense growth of blue-green algæ, Mr. Stearns, the chief engineer of the board, suggested that surveys be made to discover, if possible, suitable ground, conveniently situated, on which to pour intermittently the water of the reservoir and to collect it again at lower levels in wells and springs. It is probable that continuous filtration would be inapplicable to water of this kind, for the jelly-like masses which are secreted by these algæ would probably close the pores of the filter in a very short time. With intermittent filtration the deposit of organic matter in the pores of the sand would dry out or become oxidized when the ground was more or less dry.

It has been to many a difficult matter to explain how filters working continuously, and constantly covered with water, could intercept objects so much smaller than the spaces between the particles of sand. It was easy to imagine that some of the minute suspended particles might be caught between the particles of sand, but that practically all the suspended matter, even the minute bacteria, could be removed in a good working filter, seemed to indicate that the efficient working of a filter depended on the fact that it became nearly clogged on the surface by the algæ and other matter which held back even the smallest objects. But if this were the case, it would save time to use a finer sand at the outset, which experiment shows will not accomplish the purpose.

Piefke has given us the clearest conception of the action of sand filters in removing the suspended matters, including bacteria, from surface waters. The chemical effect is very slight, as might be supposed when one reflects that the duration of the passage of water through the sand seldom, if ever, exceeds five and one-half hours, and, since the filter is kept constantly covered, there is no oxygen present but that dissolved in the water. But the mechanical effect in removing suspended matter—mineral and organic—is very great. The Spree water, which forms part of the supply of Berlin, contains as high as 100,000 bacteria per cubic centimeter at times, and the number in the filtered water rarely exceeds 100, that is, the reduction of bacteria may reach 99·9 per cent. The thickness of the sand layer is generally from 2' to 3', and this rests on a layer of coarser gravel, which is without any effect on the filtration. The size of the sand is seldom finer than one-fiftieth of an inch, which leaves channels between the grains that 500 micro-organisms could pass abreast. Smaller still are the particles of clay which give a milkiness to water, and yet when one of these sand filters is working well, both clay and bacteria are held back in the sand.

It takes a new filter about two weeks to get to its maximum efficiency, and if the sand be first carefully cleaned and sterilized by heat, then it takes much longer, many weeks, before the filter works well.

On examining with the microscope the surfaces of the particles of sand when the filter is in perfect working order, they are found to be coated with a greasy, slimy substance which is a mass of bacteria jelly. Piefke found in a kilogramme of sand taken from the surface of a filter 5,600,000,000 bacteria; just below the surface 734,000,000, and at the depth of a foot 92,000,000. These numbers, he says, are far below the truth, because of the difficulty of cleaning the particles of sand thoroughly. It is to this coating of bacteria jelly that Piefke attributes the efficiency of these filters, and until the jelly forms in sufficient amount to completely envelop each particle of sand, the filters work imperfectly. This, then, is his explanation of the fact that minute micro-organisms and particles of clay of infinitely smaller size than the channels in the sand are stopped in their passage through it—they are simply caught in this slimy coating and cannot get further.

A filter of this kind is, like that used in intermittent filtration, a very delicate instrument, and it is very easy to disarrange it. Disturbance of the sand or suddenly increasing the pressure of the water may have, as a consequence, a rush of bacteria into the filtered water. Quite regular working is an essential condition of success. The rate of filtration is on an average only four inches vertically an hour, so that in the passage of the water through the sand, one third of which is interstitial space, its rate is three times as great, or twelve inches an hour, and the sand layer being two feet thick, the water is in contact with the sand only two hours. In very turbid waters or waters very high in bacteria the filtration is often decreased to one-half this rate or even less, and in comparatively clear water, with low bacteria, the rate may be doubled. The working of the filters in Berlin is governed entirely by the number of bacteria in the filtered water, this being the simplest way of judging of the efficiency of their working. One hundred bacteria per cubic centimeter in the filtered water is considered a good result on the Spree water, which contains always many thousands. To give practically sterile water would require a diminished rate, say to one vertical inch an hour, which would be impracticable without enlarging the filtering plant.

The surface waters used to supply London from the Thames or the Lee are filtered by the method of continuous filtration, a surface of one hundred acres being required for the purpose. The thickness of sand differs with the different companies supplying the city with water, from two feet at the East London and Grand Junction companies to four and a half feet at the Chelsea company, and the rate of filtration per hour in imperial gallons per square foot of filtering surface is two and one-sixth with the Lambeth company, to one and one-half gallons with the Southwark & Vauxhall Co. Two and one-half gallons or five vertical inches an hour (which is seldom attained) is considered the maximum consistent with good clarification. Complete analyses are made of the water supplied to the metropolis by the different companies. Some of the determinations, as for instance color, and the amount of permanganate to oxidize the organic matter, are made daily, other chemical determinations are made weekly. The monthly determinations made by Dr. Percy F. Frankland of the bacteria in the waters of the different companies have been suspended since December, 1888. The average reduction of the number of micro-organisms present in the waters of the Thames and Lee was, in 1887, 97·6 per cent. in the case of the Thames, and 93 9 in the case of the Lee. "If," says the report on the metropolitan supply for December, 1888, "these figures could be accepted as at all representing the degree of security given to consumers of the waters of those rivers by preliminary filtration, it is evident that the views on this subject acquired by a consideration merely of the results of comparative chemical analysis of filtered and unfiltered waters would have to be considerably modified and the character of the water supply would be correspondingly raised in public estimation. Further, if the results obtained from month to month could be relied on as an index to the effect of filtration in eliminating objectionable matters from the water, the bacteriological method would seem to afford a delicate and easily applied test of the working efficiency of the filter."

The average numbers of bacteria in the water of the Thames is generally less than in the Spree at Berlin; thus during the year ending December, 1887, the highest number in November was 81,000, and the lowest in June was 2,200, the average for the year being 21,492.

The only filtering plant in this country, that I know of, which at all compares with the plants in Europe is that at Poughkeepsie, where the Hudson River water is converted into good clear water, though not absolutely free from color. Mr. Fowler, the superintendent of the works, writes me with regard to the details of the filtration: "Our usual rate of filtration is about six inches per hour, vertically, and this we regard as the maximum of efficiency, although we can sometimes do good work, so far as clarifying is concerned, at double that rate, and at other times are unable to do good work at one half that rate, although the latter condition is exceptional. Very much depends upon the condition of the water in the river. The depth of water on the sand varies from one to three or four feet, and the difference of level between the surface of the water on the beds and that in the intermediate basins is usually two to four or five feet."

The rapid filtration of water through coarse gravel is not unfrequently carried out at water works to remove the larger particles floating in the water. When a filter of this kind is cleaned it is surprising to see the amount of fine dirt of all kinds that has been intercepted by the coarse material. Filters of this character do not pretend to purify the water in the sense of removing bacteria or in oxidizing the organic matter, but they are useful just to the extent to which they clarify the water and thereby improve its appearance.

The American system of filtering large quantities of water may be said to be the mechanical filters working under pressure. These filters are composed of four or five feet of moderately fine sand (some have also a mixture of coke) inclosed generally in boiler iron cases. They work with tremendous rapidity, sometimes over a hundred vertical feet an hour, but forty feet is said by some to be the highest rate consistent with good filtration. In this system alum is generally added to the water as a coagulant. Its effect in very small amount is quite remarkable—say a grain to a gallon or even less—in retaining the solid matters of the water in the sand of the filter. The alum is decomposed by the carbonates in the water, and hydrate of alumina is precipitated. This is a gelatinous and slimy substance, and immediately surrounds the algæ, clay, and anything else that may be suspended in the water, and the sand retains this coagulated mass. Alumina has also the effect of taking the color out of water, so that clear, colorless water may be obtained by this process from swampy waters full of growing algæ, with almost incredible rapidity.

These filters are in very general use in paper mills and other industrial works where a clear, colorless water is needed, and where a colored, turbid river water is the only natural supply available. They have also been introduced into some cities of considerable size, as, for instance, Long Branch, Chattanooga and Atlanta, and they are said to give water that is satisfactory to those who use it. The objection to the system is the use of alum. If all the alum used were decomposed in the few seconds that it takes the water to pass through the filter, so that no undecomposed alum passed into the filtered water, there might be no objection to its use, but this is not always the case. The amount of alum used is ordinarily small and it is claimed that if it even all went into the filtered water it would not injure it for drinking. This may be so, but the prejudice that exists against drinking water which has been treated with "chemicals" is so strong that it is not likely that any system using a coagulant in a soluble form will find general acceptance. Under some conditions when the water has high color with much suspended matter the alum has to be increased largely to give good results. I have known as high as seventeen grains to the gallon to be used with a very bad swampy water.

In this connection should be mentioned the spongy iron filter of Bischof, which gives most excellent results both in taking out suspended matters from the water, including the bacteria, and also decreases the hardness of the water. This filter has been used on the small scale in houses, and also on the large scale in Antwerp to decolorize and otherwise purify the water of that city. The filter is composed of finely divided metallic iron made by reducing iron ore by means of carbon at a temperature below fusion. Its

action was not understood for a long time, and the mystery that surrounded it was an additional recommendation for it. The *rationale* of its working seems to be this, namely, that the iron being in a very finely divided state is dissolved to a slight extent by the combined action of the oxygen and carbonic acid in the water, and the ferrous carbonate thus produced is further oxidized, forming hydrate of iron, and then this acts as a coagulant just as the alumina hydrate does. The system was said to be too expensive on a large scale, and it has now been replaced at Antwerp by the Anderson process, in which the dark water is made to pass through a long revolving iron cylinder, in which there is a large quantity of fragments of cast iron. These fragments of iron in their friction one on the other are abraded, minute particles are broken off which are dissolved in the way above described. The water coming from the revolving cylinder is exposed to the air, the iron oxidizes and precipitates, combines with the coloring matter in the water, incloses the solid particles, and is then filtered out through sand. The process is said to work satisfactorily and give clear, colorless water. There is no objection to this use of iron as a coagulant, provided that it is all oxidized and precipitated, and none is carried in solution into the filtered water; but this takes time.

Both alum and iron salts have a tendency to sterilize water. Their action may be both direct, by killing the bacteria, and indirect, by removing them with the precipitated alumina or iron hydrate. If a drop of a solution of alum or of iron chloride be added to a gallon of water, it will become perfectly clear in the course of a few hours, the alumina, or iron hydrate, which is formed in the water, settling to the bottom and carrying all the suspended matter with it. It has been proposed to clarify Mississippi water by adding a very small quantity of an iron solution to the water in the settling basins.

I have laid some weight on the desirability of following nature's processes in the purification of impure waters. Neither the American system with its mighty rush of waters, nor the European system with its calm, steady, and deliberate flow, finds any analogy in nature. In the rapid-working mechanical filters a coagulant is used to grasp and hold the suspended matter; in the continuously-working filter beds the bacteria are put to a novel use in retaining the solid matter on the sticky surface of the sand.

Nature uses these methods also. She removes color by means of clay in the soil and intercepts mechanically in the bacteria laden soil all the solid matter in the water, but she goes further than this and, giving the bacteria full play, breaks up the organic compounds and leaves no trace of their existence behind. To do this time is needed. "The bacteria of nitrification," as Dr. Smart has well said, in referring to the system of rapid filtration, "cannot be harnessed to the work of artificial filtration."

The rate at which nature works may be expressed in the amount of rain-fall. If we take the rain-fall at fifty inches, and assume that even half of this sinks into the ground (a very high estimate), we have twenty-five inches yearly on a square foot of surface. The amount of water that goes through the Berlin filters, at a rate of four inches an hour, is more than 1,250 times this amount. If we wish to imitate the process by which nature makes its springs, we must pour the water from river or lake which we wish to filter intermittingly on the surface of ground which is favorable for this purpose. The favorable conditions are these, the ground must be sufficiently porous to allow the ready flow of water through it, and it must have such relations to the strata below as will enable us to collect the water at some lower level. It would not profit us much to pour the water on to a gravel bed if we could not find it again after it had been filtered. If the natural conditions for this purpose are not favorable, drains would have to be put in at suitable depths to collect the filtered water. Water purified in this way would in nowise differ from natural spring water, provided that the amount of water applied did not exceed the capacity of the filtering area.

The question of the maintenance of the purity of the water supplies of large cities, which are dependent upon surface waters, is daily becoming more urgent in this country as the population becomes more dense on the collecting areas, and the protection of streams against pollution becomes more and more difficult. The radical remedy in such cases is to take water from another and, usually, more distant region, which, it is probable, will never become thickly settled. But in filtration, both intermittent and continuous, when intelligently conducted, we have a substitute which can give us clear, colorless, and, we have good reason also to suppose, safe drinking water.—*Jour. of the Association of Engineering Societies.*

THE TREATMENT OF HÆMORRHOIDS.*

By CARTER B. HIGGINS, M.D., Surgeon in Charge, Wabash Railroad Hospital, Peru, Indiana.

THE treatment of hæmorrhoids by forcible dilatation of the sphincters was, I think, first publicly advocated by the eminent French surgeon Verneuil about sixteen years ago. At that time he professed to have radically cured many cases of the most aggravated character. Immediately following Verneuil's came other statements emanating from French surgeons of the highest standing, all confirming in the most positive manner the wonderful effects of dilatation of the sphincters in the treatment of piles. That treatment so simple, advocated with such earnestness by surgeons of unquestioned ability and integrity and of world-wide reputation, should attract so little attention is indeed wonderful.

Allingham's is about the only text book on rectal surgery which gives the treatment by dilatation respectful notice. He says it may succeed in selected cases, but must not be thought of as a general treatment. Andrews, not having given the method a trial, says it may be desirable in cases of timid patients who cherish a horror of ligatures and instruments. (I wonder if he comes in contact with any who do not.) Kelsey barely mentions the treatment as not worthy of consideration. Since taking charge of the Wabash Railroad Hospital I have had in my service six house surgeons, graduates from four different medical colleges, all high-grade schools. These young gentlemen received appointment on account of high standing in their classes. Not one of them previous to coming here had ever heard dilatation of the sphincters recommended as a curative method in the treatment of piles. Three or four articles have appeared in as many different medical journals published in the United States advocating the treatment. With these exceptions I have failed to see it commended by either English or American authority.

My confidence in the superiority of the treatment by dilatation was secured by the same nature of accident which convinced the French surgeons—that is, by observing the complete and permanent disappearance of a number of large internal pile tumors in the case of a gentleman who, in connection with his other trouble, developed an anal fissure, dilatation for the cure of which also cured his hæmorrhoids. Dr. Brenton, of this society, reports similar experience, his patient being a lady who had suffered greatly both from strangulation of the tumors and great loss of blood; her fear of any operation suggested for the cure of the piles was too great to be overcome, but the fortunate intervention of an anal fissure induced her to consent to the procedure of dilatation, with the result of curing both fissure and hæmorrhoids and her speedy restoration to perfect health.

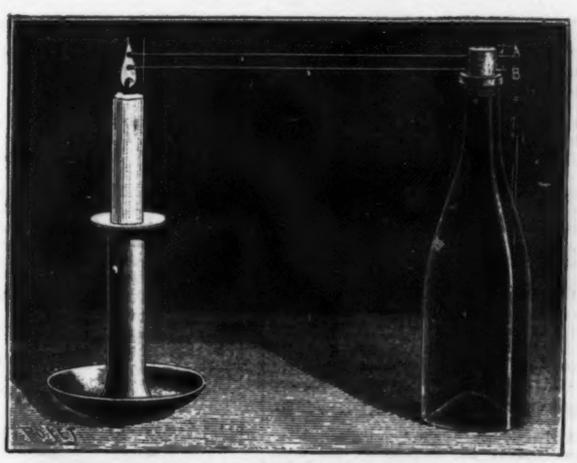
I have used no other method in effecting the radical cure of piles for the past eight years, and during that time have succeeded in curing many cases of the most aggravated character. I will not now state the number of cases nor the percentage of cures, realizing that advocates of new methods too often excite distrust by alleging too much. I know of no condition that would forbid the application of this treatment. I have applied it at almost every stage of pregnancy, in four hours succeeding labor, in patients suffering from cirrhosis of the liver far advanced, in cases complicated with enlarged and indurated prostate gland, those with urethral stricture—in fact, I know no reason, where it is demanded for relief, why it should not be resorted to. In 1888 Verneuil reported the results of his application of the treatment during the fourteen years then just passed. He alleged 98 per cent. of cures. He made no distinction in the cases, "both external and internal, old and recent, large and small, those associated with relaxed sphincters and those with the opposite condition." My experience with the treatment has been no less satisfactory than that reported by Verneuil. My percentage of cures would be increased by eliminating two cases of applicants for pensions, piles being the alleged cause of disability. The applications were still pending when they reported slight if any improvement.

The dilatation is effected as follows: Hook the thumb of your left hand and the middle finger of your right hand so as to include both sphincters on opposite sides of the anus, and gradually but forcibly separate your hands until all resistance ceases, the object being to paralyze the muscles completely. It is commonly advised to oppose the thumbs, but in a great many cases the resistance will be found so strong that it will be impossible to separate the thumbs a sufficient distance. I have in some cases found the sphincters from long contraction developed to such a degree as to give the impression of pulling on an iron ring. I have never known any bad results follow the procedure. No after treatment is necessary, except in cases where there is complaint of smarting, which may be relieved promptly by the application of a pledget of cotton saturated with a four per cent. solution of cocaine. It is always advisable to perform dilatation under the influence of an anæsthetic, the A. C. E. mixture being the one I always use.—*N. Y. Med. Jour.*

* Abstract from a paper read before the Miami, Ind., County Medical Society, July 18, 1890.

EXPERIMENT IN CONDUCTIVITY.

THE conductivity of metals may be easily observed and demonstrated as follows. Take a piece of iron wire or a knitting needle and a piece of copper wire of the same length and of nearly the same section. Heat these in the flame of a candle and then pass them through the latter. Then, holding them vertically, allow them to cool. They will remain covered with a thin layer of solidified stearic acid. Next, insert the extremities in a cork supported by a bottle. Then heat the free extremities, and, in measure as the heat is propagated, the stearic acid will melt and form a globule, that will run along each wire, thus very clearly showing the spread of the heat (see figure). The globule will run more quickly and to a greater distance upon the copper than upon the iron, and this indicates that the former is a better conductor of heat than the latter.—*La Nature.*



EXPERIMENT IN CONDUCTIVITY.

EXPERIMENT IN CENTRIFUGAL FORCE.

AT dessert, when a wine bottle is empty, drain it thoroughly and ask those who are present how much wine they suppose can still be made to fall in drops from the bottle. Some will say ten drops, others twenty drops, etc. You can bet on several hundred. To verify this statement, take a sheet of blotting paper, and incline the bottle in order to show that it is empty and that not a single drop more comes from it. Then, raising your arm, make the bottle swiftly describe an arc of a circle. The centrifugal force will project a number of small drops, which will appear innumerable on the blotting paper. This experiment may be repeated several times, and drops will appear every time.

EXPERIMENT IN CENTRIFUGAL FORCE.

This experiment is more successful when tried upon the floor. Place the paper upon the floor, and, leaning over, with the legs wide apart, hold the bottle in both hands neck downward. Make the bottle swiftly describe an arc of a circle a few inches above the paper. —*La Nature.*

WHY OIL CALMS THE SEA.

THE action of oil in calming the sea is now so generally recognized that in the rules as to life saving appliances made under the act of 1888, and which are to come into force on the 1st of November, it is provided that all lifeboats shall carry as part of their equipment: "One gallon of vegetable or animal oil and a vessel of approved pattern, for distributing it in the water in rough weather." In sea-going vessels which are not required by the rules to carry a lifeboat, it is prescribed that each boat which they do carry shall be similarly provided. The apparent inadequacy of the means to the end has caused much skepticism as to the value of oil as a means of stilling waves, and this is vanishing only in the face of incontestable practical evidence of its utility. The very antiquity of the practice likewise tends to retard its revival in the present day. In the middle ages oil was frequently used to still the waves of the sea, but it was usually after being consecrated by some religious ceremony, or else in connection with supernatural art, where the incantation of the magician was the potent force and the oil a mere accessory. So when the virtue of a bishop's blessing and the potency of the black art were no longer relied upon, men also ceased to put confidence in the humble accessory, and no longer believed in the virtue of a pint of oil to still the waves of a large surface of troubled water.

Now that we are forced to recognize that after all our forefathers were right in their facts if wrong in their theories, the effect of oil being undoubted, even if it had remained inexplicable, it is of great interest to learn what science has to say on the matter. At a recent meeting of the Royal Institution, Lord Rayleigh gave an interesting lecture entitled "Foam," in which he considered in detail the phenomena of liquid

films, and in the course of which he gave some explanation of the reason why very small quantities of oil are effective in stilling a large area of troubled water.

Foam or *froth* is, according to Lord Rayleigh, caused by the presence of impurity in liquids. Thus, on shaking up a bottle of absolutely pure water, we get no appreciable foam, and similarly we get none by shaking pure alcohol; but taking a mixture of water with 5 per cent. of alcohol, there is a much greater tendency to foam. Some of the liquids we are most familiar with as foaming, such as beer or ginger beer, owe the conspicuousness of the property to the development of gas in the interior, enabling the foaming property to manifest itself; but, of course, the two things are quite distinct. Thus beer, from which all the carbonic acid has been extracted, still foams freely on being shaken up. Camphor, glue, and gelatine are substances which, when dissolved in water, increase its foaming qualities greatly, even though they are present in very small quantities, such as 3 parts in 100,000. They are, however, as is well known, exceeded in this quality by soap, and also by *saponine*, which is made from an infusion of sliced horse-chestnuts. The foaming of rivers is, doubtless, caused by the presence in the water of minute quantities of saponine, or some analogous substance. Sea water foams not on account of the saline matter which it contains, for it may be shown by experiment that even a strong solution of pure salt does not foam much, but in consequence of the presence of something extracted from seaweeds during the concussion which takes place under the action of breakers. Foaming, then, is due to the durability of the films of a liquid.

Lord Rayleigh, in the course of his lecture, exhibited a number of experiments in illustration of the properties of liquid films. One of the most interesting was as follows: Some camphor scrapings were spread on a surface of pure clean water, and they immediately commenced to move vigorously, while the camphor was dissolving. "But," he says, "if I now contaminate the water with the least possible quantity of grease, the movements of the camphor will be stopped. I merely put my finger in, and you observe the effect—a very slight film perfectly invisible by ordinary means is sufficient so to contaminate the water that the effect of the dissolved camphor is no longer visible." In a previous experiment of the same kind Lord Rayleigh had used a sponge bath 3 ft. in diameter, and took means to ascertain the very small quantity of oil necessary to produce the effect, and from that the thickness of the film; which was about one and a half millionths of a millimeter, or the 380,000,000th part of an inch. The effect of merely stopping the movement of camphor scrapings on the surface of water is, of course, a very small affair, but the wonder is how a film of oil of such extreme tenuity can hold together at all so as to produce any effect.

Franklin appears to have been the first scientific man who experimented on the effect of oil on waves. His attention was called to it accidentally on board ship from noticing the effect on the waves caused by the greasy *debris* of a dinner. The captain assured him that it was due to the oil spread on the water, and for some time afterward Franklin used to carry oil about with him so as never to miss a chance of trying an experiment.

In speaking about the effect of oil on waves a distinction must be observed. It is not that the large swell of the ocean is damped down; that would be impossible. The action in the first instance is upon the comparatively small ripples. The large waves are not directly affected by the oil; but it seems as if the power of the wind to excite and maintain them is due to the small ripples which form on their backs, and give the wind, as it were, a better hold of them. It is only in that way that large waves can be affected. The immediate effect of oil is on the small waves, which conduce to that breaking of the large waves which from the sailor's point of view is the worst danger. It is the breaking waters which do the mischief, and these are quieted by the oil. For the explanation we are indebted to Marangoni, an Italian physicist, and to Reynolds and Aitken. "The state of the case," says Lord Rayleigh, "appears to be this: Let us consider small waves, as propagated over the surface of clean water; as the waves advance, the surface of the water has to submit to periodic extensions and contractions. At the crest of a wave the surface is compressed, while at the trough it is extended. As long as the water is pure there is no force to oppose that, and the wave can be propagated without difficulty; but if the surface be contaminated, the contamination strongly resists the alternate stretching and contraction. It tends always, on the contrary, to spread itself uniformly, and the result is that the water refuses to lend itself to the motion which is required of it. The film of oil may be compared to an inextensible membrane floating on the surface of the water, and hampering its motion; and under these conditions it is not possible for the waves to be generated, unless the forces are very much greater than usual. That is the explanation of the effect of oil in preventing the formation of waves. The all-important fact is that the surface has its properties changed, so that it refuses to submit to the necessary extensions and contractions."—*Nautical Magazine.*

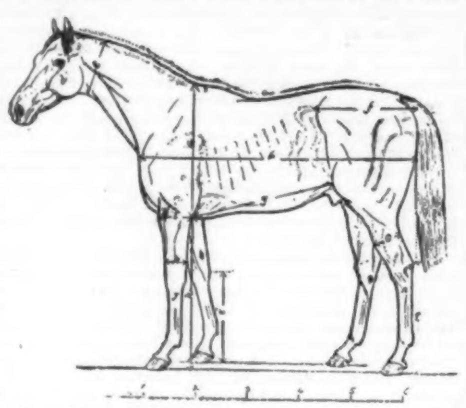
MEASUREMENTS OF ORMONDE.

THIS celebrated English race horse has been sent to South America. Just before his departure for that country an expert took his "measurements," and his figures are illustrated by the diagram, which is re-engraved from the London *Live Stock Journal.* The following table fully explains the diagram:

EXPLANATION OF DIAGRAM OF ORMONDE.

	Ft.	In.
a Height: 16 h. 1½, or	5	5½
b Entire length from greatest projection of chest to greatest projection of quarter	5	4
c Entire length from occiput (between ears) to root of tail	6	10
d Length of head	2	1
e Neck, narrowest part	1	1
f From the "pin" or focus of the hair growth immediately in front of ilium to the extreme projection of quarter	2	0
g From elbow to stifle	2	9
FORK EXTREMITY.		
h From ground to elbow	3	0
i From ground to trapezium (back of knee)	1	8½
j Width below knee	0	3
k Width immediately above knee	0	4¾
l Width of arm at elbow level	0	7½
HIND EXTREMITY.		
m From ground to point of calcis (hock)	2	2
n Width below hock	0	3½
o Width above hock (second thigh or gaskin)	0	6½

This plan of measuring celebrated horses is a good one. It would be well if such diagrams could accompany portraits of animals. This is a suggestion for some of our live stock breeders. Such diagrams would add a good deal to the value of their catalogues.—*Rural New-Yorker.*



MEASUREMENTS OF THE RACE HORSE ORMONDE.

THE

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